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MANUFACTURE OF LITHIUM RESERVE CELLS

Robert J. Horning, et al

Honeywell, Incorporated

Prepared for:

Picatinny Arsenal

July 1974

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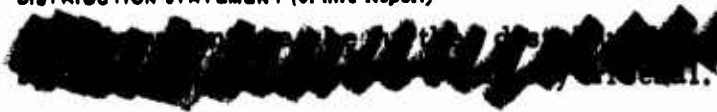
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The purpose of the program was the manufacture of 1200 lithium reserve cells as defined in a technical data package developed under a prior contract, DAAA21-72-C-0437, issued by Picatinny Arsenal in February, 1972. This objective was satisfactorily achieved with the submission of three lots of cells to the sponsor and the successful completion of acceptance tests performed with samples from each group.		

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Block 20, continued

The cell manufactured is a small one having a diameter of 0.5" and a height of 0.835". Nominal voltage is 3.2 volts and the maximum capacity to a 2.5 volt minimum is 100mAhrs. The unit is capable of efficient operation over a temperature range of -35 to +135°F, of very long intervals of unactive storage and of surviving severe environmental conditions of shock, spin, acceleration and rough handling.

During the effort, a significant process problem involving leakage at the glass-to-metal seal of the negative terminal was encountered during the manufacture of the second lot. This was corrected after a substantial engineering effort on the part of Honeywell and suppliers of the component. Design and process improvements resulting from this activity are discussed in the report.

Block 19, continued

Cathode-Vanadium Pentoxide

Electrolyte - Lithium Hexafluoroarsenate

Lithium Tetrafluoroborate

Methyl Formate

Glass-to-metal seal

Hermeticity - Leakage Testing

Electron Beam Welding

Cell Manufacturing

ia

FORWARD:

This report documents the technical effort conducted by Honeywell in compliance with Contract DAAA21-73-C-0677. This report is being submitted to Picatinny Arsenal in accordance with contract requirements. The contract was begun in May 1973 and was initially anticipated to have been completed by October 1973; however, the occurrence of process difficulties that delayed the delivery of required hardware necessitated the execution of a Contract Modification (P00001) that extended completion to December 1973.

The purpose of the contract was to manufacture 1200 lithium reserve cells as defined by the technical data package developed under a prior contract, DAAA21-72-C-0437, issued by Picatinny Arsenal in February 1972. This objective was met in addition to the completion of a significant amount of process investigation relative to a key component, the terminal plate glass-to-metal seal, a description of which is presented in this report.

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SUMMARY:

The manufacture of 1200 lithium reserve cells per Picatinny Arsenal P/N T9275567 was accomplished within this contract. The cells were manufactured in three lots; PR-1, 380 units; PR-2, 218 units; and PR-3, 602 units. From each lot, a sample was selected and tested for acceptance in accordance with the procedure given in Appendix B of the contract which requires the fabrication of two cell power sources utilizing stab primers for activation as developed under Contract DAAA21-72-C-0437. Acceptance testing, including the power source fabrication, was accomplished at Picatinny Arsenal.

The cells manufactured conformed to Picatinny Arsenal P/N T9275567 with the exception that the case material was type 316L stainless steel and the electrolyte was of the formulation $2M LiAsF_6$ (U.S.S.) + $0.4M LiBF_4/MF$. During this contract, the technical data package was revised to include these modifications.

Two difficulties were encountered and corrected during the course of this program. The first, a failure of one power source in the PR-1 acceptance tests, which was traced to an out of tolerance condition on a component of the anode electrode which was subsequently reconfigured to eliminate occurrence thereafter. The second more significant problem involved the integrity of the glass-to-metal seal in the terminal plate of the cell. A significant number of the PR-2 lot were found to have defective seals during final inspection causing a substantial reduction from 400 in the number of units submitted in this group. Investigation found the seal was developing fine leaks as a result of thermal stresses encountered during the final weld sealing of the cell.

The problem was encountered with components obtained from a new source that was necessitated when the prior vendor was no longer available. The seal problem was corrected and cell deliveries resumed after a large effort was expended which involved the improvement of seal quality from the vendor and weld process modification. The latter was specifically a change in the method of heat sinking the cell during final welding. An additional result of this effort was the identification and evaluation of terminal seals from two more vendors, one of which has since supplied acceptable components in large quantities.

There were three other smaller tasks accomplished during this program and reported herein. First was the evaluation, by a 40 cell test plan, of the environmental susceptibility of the fine leak inspection rejects generated from the PR-2 cell lot. Second was the preliminary investigation of an alternate welding technique, tungsten inert gas (TIG) and finally the design and procurement of cathode tooling capable of component production at a faster rate.

The primary objective of cell manufacture was accomplished with delivery of the required amount of hardware in a modified schedule of submission from the contract scope of work. Problems encountered in the achievement of this objective have been solved and have served to improve the quality and manufacturing status of the cell and the components.

SECTION I

1.0 PROGRAM OBJECTIVES

1.1 The objective of Contract DAAA21-73-C-0677 was the manufacture, inspection and engineering design modification of 1200 lithium reserve cells as defined in the technical data package developed and submitted under a prior contract from Picatinny Arsenal, DAAA21-72-C-0437.

1.2 Scope of Work

1.2.1 The initial program plan required the delivery of the 1200 cells in lots of 400 each scheduled at monthly intervals. The first lot (PR-1) was submitted per plan; however, the schedule on the remaining two was significantly affected when difficulty with the integrity of the terminal plate glass-to-metal seal was encountered in Lot PR-2. An interim period of time was required to correct the problem after which hardware commitments were satisfied. The activity associated with the terminal seal is discussed in Section 4.1 of this report.

1.2.2 The contract required the sampling from each lot, a number of cells for acceptance testing which would be conducted at Picatinny Arsenal. Initially, the sample was to be 36 cells from each group of 400; however, the quantity was adjusted upward for the last lot (PR-3). This was done because of the increased number of units (602) in the group as a result of shrinkage incurred in the earlier lots from the difficulties encountered.

1.2.2.1 The testing of the samples for acceptance would be in the two-cell power source configuration that uses a stab primer for activation of

the cells. The significant acceptance requirement is that all power sources have an active life above 5.0 volts for not less than 60 hours when under a load of 6.6K ohms. This requirement applied for cells tested at all of the three thermal environments employed - -35°F, ambient room and +135°F.

- 1.2.3 Under the heading of engineering design modification, there was, during this program, process development effort applied in the areas of cathode fabrication and outer case closure welding. The cathode work involved the design and procurement of tooling capable of more efficient component manufacture and the welding activity was concerned with the preliminary evaluation of an alternate technique to electron beam welding referred to as TIG (Tungsten Inert Gas). Section 7.0 contains the discussion relating to this portion of the program.

2.0 BACKGROUND

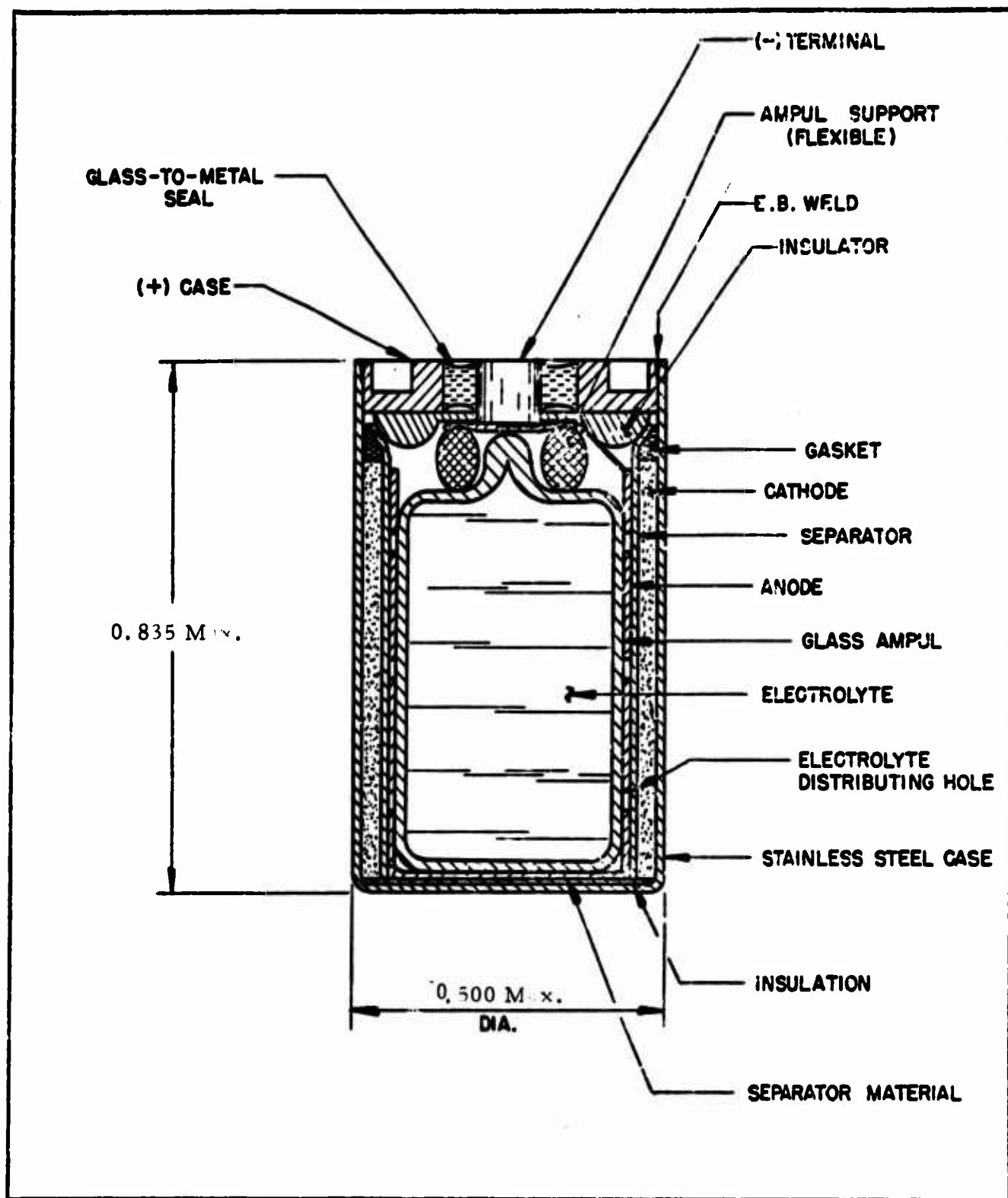
2.1 The design and qualification to developmental requirements of the cell to be manufactured during this program were accomplished under contract DAAA21-72-C-0437, awarded to Honeywell by Picatinny Arsenal in 1972. Included in that eighteen month effort was the preparation of a technical data package that has served as the baseline documentation for subsequent activities.

2.2 The scope of this first subsequent contract to the initial effort provides for the manufacture of a substantial quantity of cells in comparison to the hardware commitments of earlier work. Fabrication of units on this larger quantity scale provided experience helpful in accomplishing design and process improvements to the baseline configuration.

2.3 The item manufactured in this program is generically referred to as a primary lithium reserve cell. Primary because of a single discharge capability, lithium in reference to the highly energetic anode material and reserve because the cell is designed to remain inactive prior to discharge for long intervals of time during which there is no significant loss in output capability. The last feature is accomplished by isolating the electrolyte solution from the electrodes during the inactive period by containing it in a sealed glass ampul within the cell.

2.4 A cross-sectional diagram of the cell is given in Figure 1 and shows the internal configuration of the electrodes and other components.

2.4.1 The cell is of right cylindrical construction, having concentric electrodes placed about a centrally located glass ampul that contains the electrolyte.



FORM FM-100

FIGURE 1
PRIMARY LITHIUM RESERVE BATTERY
REFERENCE PICATINNY PRINT NO. T9275567

- 2.4.2 The outermost electrode is the cathode, a blend of vanadium pentoxide (V_2O_5) and graphite, having a theoretical capacity of 100 milliampere hours when discharged to a 2.5 volt minimum voltage.
- 2.4.3 Adjacent to the cathode is a glass fiber separator next to which is the innermost electrode, the anode. The anode consists of lithium metal pressed on an expanded metal screen, also of stainless steel. The capacity of the anode is nominally at 30⁰ milliamperes.
- 2.4.4 The electrolyte in the ampul is a solution of lithium hexafluoroarsenate (2 molar) and lithium tetrafluoroborate (0.4 molar) in a methyl formate solvent (2M $LiAsF_6$ + 0.4M $LiBF_4/MF$). This material has shown to be quite stable, highly conductive for an organic solvent system, and of relatively low vapor pressure (40-50 psig at +160°F).
- 2.4.5 The balance of the components are primarily insulators in the upper and lower portions of the cell that serve to prevent the internal short circuiting of the inner anode or lead with the outer positive case.
- 2.4.6 The top assembly drawing for the cell is Picatinny Print Number T9275567.
- 2.4.5 For the purposes of this program, the acceptance criteria are that the cell will function over a temperature range of -35° to +135°F for a minimum of 60 hours while providing a nominal output current of 1 milliampere. The minimum voltage that must be maintained during this period is five volts for two cells in series. Data are typically collected until the voltage decays below four volts to establish additional background on the characteristics of the system.

- 2.5.1 It is also a requirement that the power source, when activated, rise above minimum voltage within five seconds of the time when the primer is initially impacted. In actuality, this function is normally achieved in less than a second.
- 2.5.2 In addition to the acceptance requirements of this contract, the power source is also capable of meeting rather significant demands in the areas of rough handling and environmental exposure. During the developmental contract, it was demonstrated that the unit could survive accelerations of 15,000 G (9.5 ms total profile), spin of 15,000 rpm and MIL-STD environments of drop, transportation vibration, thermal shock and extreme temperature storage.

3.0 LOT PR-1

3.1 Acceptance Testing

- 3.1.1 The first lot of G2666 cells produced under this contract was submitted to Government inspection on 5 July 1973. This lot consisted of a total of 400 single cell units per drawing P/N T9275567. Representatives from Picatinny Arsenal selected a sample of thirty-six individual cells from this lot for qualification and acceptance testing. These cells were subsequently wired and potted into power source moldings and tested at Picatinny Arsenal.
- 3.1.2 The eighteen (18) resulting power sources were separated into three groups of six units. Power source numbers 1 through 6 were placed in a +135°F environment, unit numbers 7 through 12 were placed in a +70°F environment, and units 13 through 18 were placed into a -35°F environment. The units were placed in these environments approximately 2 hours before the initiation of the first activation.
- 3.1.3 Activations of all units proceeded without much difficulty. Mechanical difficulties with the activation fixtures were encountered on a number of units requiring two, and in a number of cases three, attempts at activation. The activation fixture contained an aluminum plate with a hole at the center through which the firing pin would protrude to activate the power supply. This hole would either clog periodically or the firing pins were of sufficiently large diameter to fit snugly in the hole and attempts to activate were thwarted by the firing pin not contacting the primer. In all cases, when activation occurred, battery rise times were less than 100 milliseconds.

3.1.4 Details of activations of all units are in Table 1. The closed circuit voltages listed in the table represent the first recorded voltage on the data acquisition system. Each unit is identified by a unit number and two internal cell serial numbers.

TABLE 1
LCT PR 1 ACCEPTANCE TEST

<u>Channel Number</u>	<u>Test Temp.</u>	<u>Unit No.</u>	<u>Cell Serial Number</u>	<u>Initial Closed Circuit Voltage</u>
1	-35°F	13	312 & 390	6.884
2	-35°F	14	325 & 145	6.979
3	-35°F	15	240 & 119	7.006
4	-35°F	16	98 & 311	6.955
5	-35°F	17	336 & 10	7.025
6	-35°F	18	174 & 151	7.040
7	+135°F	1	432 & 89	7.103
8	+135°F	2	378 & 15	7.128
9	+135°F	3	326 & 18	7.164
10	+135°F	4	209 & 384	7.113
11	+135°F	5	426 & 224	7.184
12	+135°F	6	388 & 317	7.183
13	+70°F	7	401 & 205	3.609
14	+70°F	8	243 & 185	7.027
15	+70°F	9	316 & 393	7.070
16	+70°F	10	223 & 287	6.948
17	+70°F	11	277 & 188	7.051
18	+70°F	12	277 & 188	7.051

- 3.1.5 Following activation, units were connected to a 100 channel data acquisition system for the remainder of the run. This system provides hard copy tape printout as well as punched paper tape output for use with the electronic data processing equipment. The schedule for these tests was as follows:

<u>TIME PERIOD</u>	<u>SCAN INTERVAL</u>
Initiation	Manual reading and hard copy printout
First hour	Five minute periodic scans - hard copy and tape
1 hour through 60 hours	Half hour periodic scans - hard copy and tape

- 3.1.6 The above test data show one cell in unit number 13 contained an internal or external short. This unit read 3.615 volts when first placed on the data acquisition system. A check of the activation trace showed this unit activated to approximately 7 volts but 0.4 seconds later the voltage dropped sharply to that characteristic for one cell. The power supply was kept on discharge for the required 60 hours, during which it functioned normally at single cell voltage. After this, the unit was removed from the test apparatus and voltage/resistance readings taken. From these, it was determined that one of the two cells, #205, was short circuited internally at a level of 0.2 to 0.3 ohms. The power source was then returned to Honeywell for a complete dissection to determine the cause of the shorted condition.

- 3.1.7 Prior to dissection of the cell, data were reviewed concerning development tests involving power sources activated with primer charges up to 2.7X normal. Sixty-six units (132 cells) were part of this testing, many of which had severe case depressions resulting from the activation force. None discharged improperly after activation.

- 3.1.8 X-rays of the power source that failed showed an unusually high case depression on cell #205, similar to that obtained in many of the multiple loaded primer tests mentioned above. Honeywell data generated in the qualification testing of the XM70 power source during the development contract for this device indicated that typical case depressions were 0.008 to 0.020 inches; whereas, it was later determined that depressions on the cell that failed ranged from 0.053 to 0.059 inches. Inspections of the other test units were made after discharge testing to determine the depressions encountered. These data are presented in test report 8310-81573 included in Appendix A of this report. In general, it showed that higher case depressions were obtained on Lot PR-1 than those that were noted in the initial qualification test program. Severe case depressions could contribute to the cause of an internal short in the cell.
- 3.1.9 Cell number 205 was then dissected and a copy of the cell post mortem findings are included in Appendix A. The short circuit was found to be between the bottom edge of the anode lead wire that is attached to the collector screen and the bottom portion of the cell casing. This surface of the case is that which depresses as a result of the primer output. The short occurred as a result of the anode lead piercing through the bottom plastic insulator and separator material that are positioned between it and the case. The anode lead itself was extending beyond the anode screen to which it is welded. This was an out of tolerance condition for the anode screen assembly. Figure 2 depicts the failure mode observed in the post mortem of this unit.
- 3.1.10 After the dissection, the x-rays of all cells in the lot were examined and it was found that twenty units had various degrees of the same problem. These units were identified, segregated and held at Honeywell as inspection rejects.

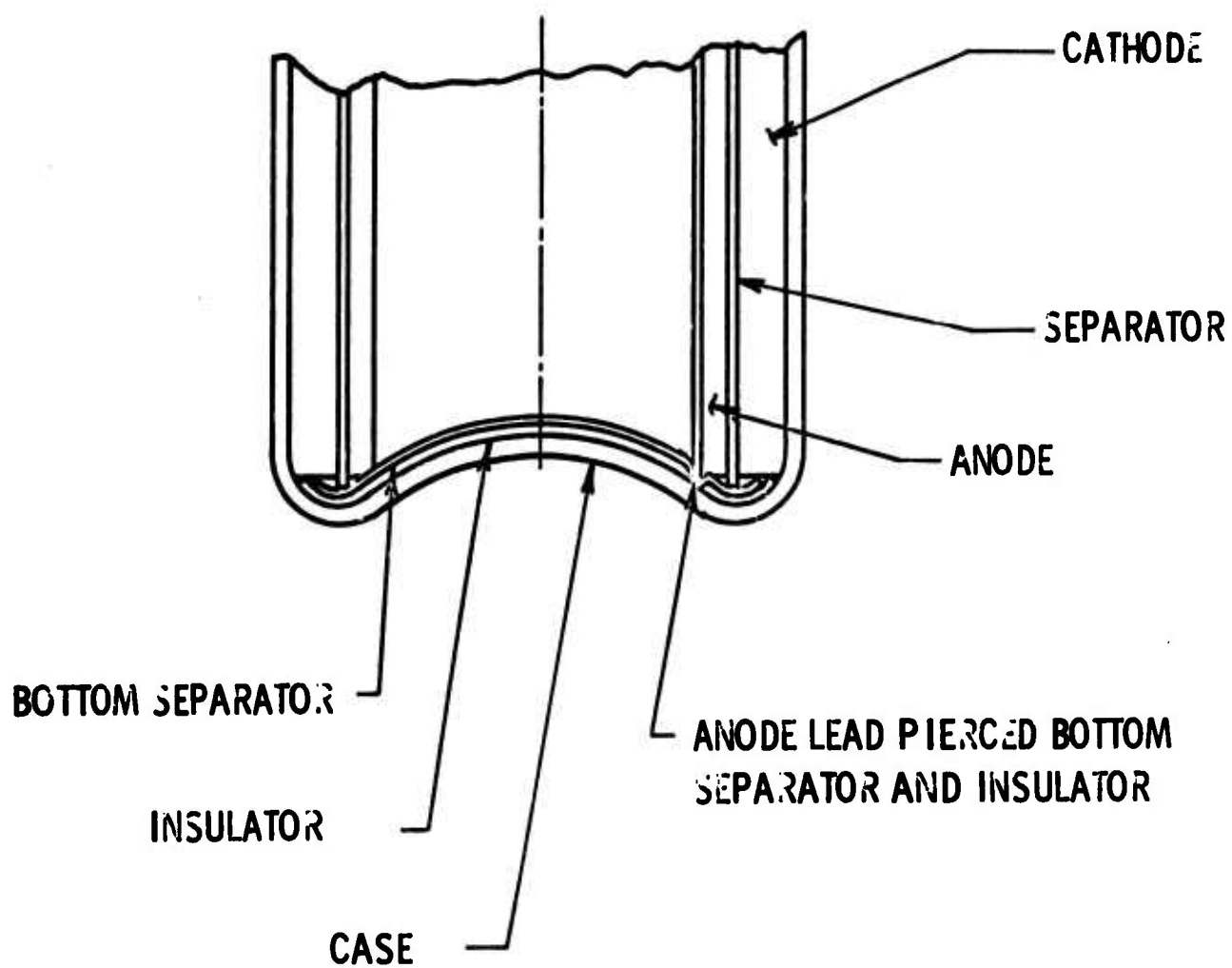
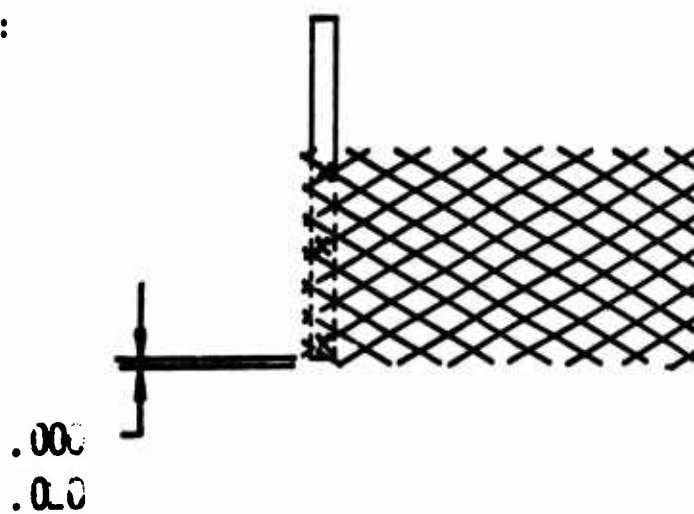


FIGURE 2

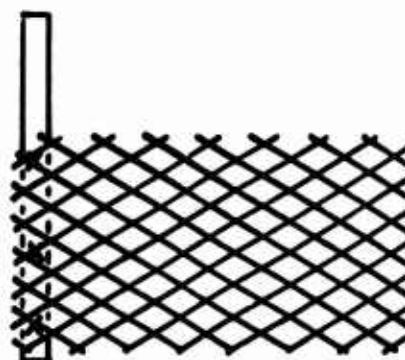
ANODE LEAD FAILURE MODE

- 3.1.11 As a result of the above findings, the cell anode grid assembly (P/N T9275574) was modified. The distance from the bottom edge of the grid to the end of the anode lead was increased to a minimum of 0.060 inches as shown in Figure 3. In order to confirm with hardware, that the above modification would prevent shorts of the anode lead to the cell case upon activation, six G2666 cells (Lot R-25) were built and tested incorporating the above design change. Test report number 8310-92673 attached in Appendix A outlines the results of this work. It was found that the above corrective measures did not affect typical cell output.
- 3.1.12 Because of the above mentioned anode grid to case shorting problem, Lot PR-1 was a reduced lot submission of 380 cells with the balance of twenty cells to be made up in subsequent deliveries. The lot was accepted on waiver with the provision that the twenty cells above be rejected as defective. The basis for this determination was as follows:
- . The cells were urgently needed in the Scatterable Mine Program to meet schedule commitments.
 - . The remainder of the tested units met acceptance requirements.
 - . There had been no previous occurrence of this type of failure.
 - . The cause of the malfunction was determined to be an out of tolerance component and not a design deficiency.
 - . The cells of the first lot exhibiting this defect had been identified and were rejected for noncompliance with the technical data package.

SPEC:



DEFECT:



RECOMMENDED:

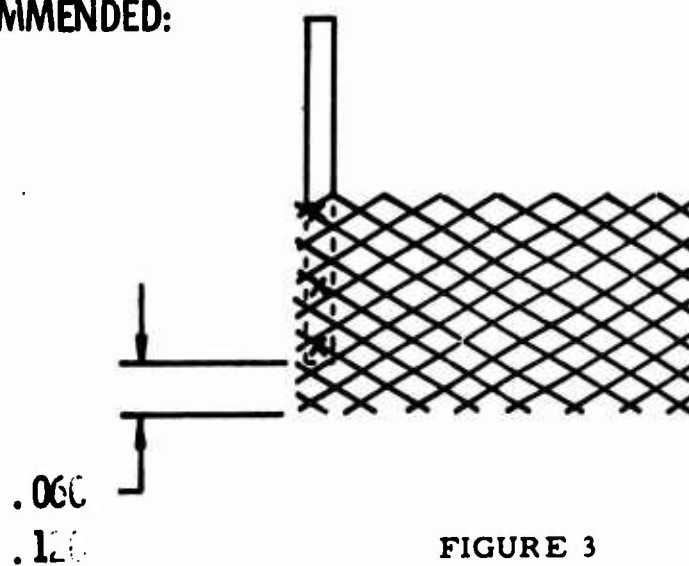


FIGURE 3

ANODE GRID ASSEMBLY CONFIGURATIONS

- . Corrective action was taken on subsequent lots.
- . Disposition of the reduced balance of the lot was as follows:
Fifty cells were sent to Picatinny Arsenal SMUPA-AD-D-M,
Dover, New Jersey 07801. Two hundred ninety-four cells were
sent to Honeywell Inc., Ordnance Division, Hopkins, Minnesota
55343.

3.2

Test Results

Figures 4, 5, and 6 represent typical voltage-vs-time discharge curves of the XM70 power sources selected by Picatinny Arsenal from Lot PR-1 for lot acceptance testing. These units were all tested using a 6.6K ohm load at -35°F, +70°F and +135°F respectively. The performance of each of the six power supplies tested at each temperature level was very predictable and very repeatable from unit to unit within any given temperature range, with the exception of unit number 13. Figure 7 shows the voltage vs. time twice associated with this unit. It was tested at +70°F and 0.4 seconds after activation the voltage dropped sharply to that of a single cell. The cause of this voltage decline which was explained previously was an internal short of the anode lead to the case. As shown in Figure 7, the unit was allowed to run at single cell voltage for the required sixty hours to obtain the single cell performance data. All other units tested met the minimum active life requirements set forth in Appendix B, page B1, paragraph IV of the contract.

BATTERY NO. 4

LOAD R (KOHMS) 6.6
 TEST TEMPERATURE 35.0 DEGREES F
 HONEYWELL DAA21-C-73-0677 S/N 98,311
 HOURS TO 5.0 VOLTS 92.0
 MA-HR TO 5.0 VOLTS 85.1
 AVG VOLTAGE TO 5.0 VOLTS 6.1 VOLTS
 AVG CURRENT TO 5.0 VOLTS .93 MA
 TEST DATE 010.7/10-24/73

CHEMISTRY LI/LIASF6 LIBF4 HF LI/V205-C
 CASE MATERIAL 316L STAINLESS STEEL



FIGURE 4
 LOT PR-1 ACCEPTANCE TEST
 TWO CELL POWER SOURCE

TIME (HOURS)
 0 50.00 100.00 150.00 200.00 250.00 300.00 350.00

BATTERY NO.

17

LOAD R (KOHMS)

6.6

TEST TEMPERATURE

70.0 DEGREES F

HONEYWELL

DAAA21-C-73-0677 S/N 382.55

HOURS TO 5.0 VOLTS

103.0

MA-HR TO 5.0 VOLTS

100.9

AVG VOLTAGE TO 5.0 VOLTS

6.5 VOLTS

AVG CURRENT TO 5.0 VOLTS

.99 MA

TEST DATE

010.7/10-24/73

CHEMISTRY

LI/LIASF6 LIBF4 MF LI/V205-C

CASE MATERIAL

316L STAINLESS STEEL

EMF (VOLTS)

12.00

10.00

8.00

6.00

4.00

2.00

0

300.00

250.00

200.00

150.00

100.00

50.00

0

-50.00

Chart provided by Picatinny Arsenal

TIME (HOURS)

FIGURE 5

LOT PR - ACCEPTANCE TEST
TWO CELL POWER SOURCE

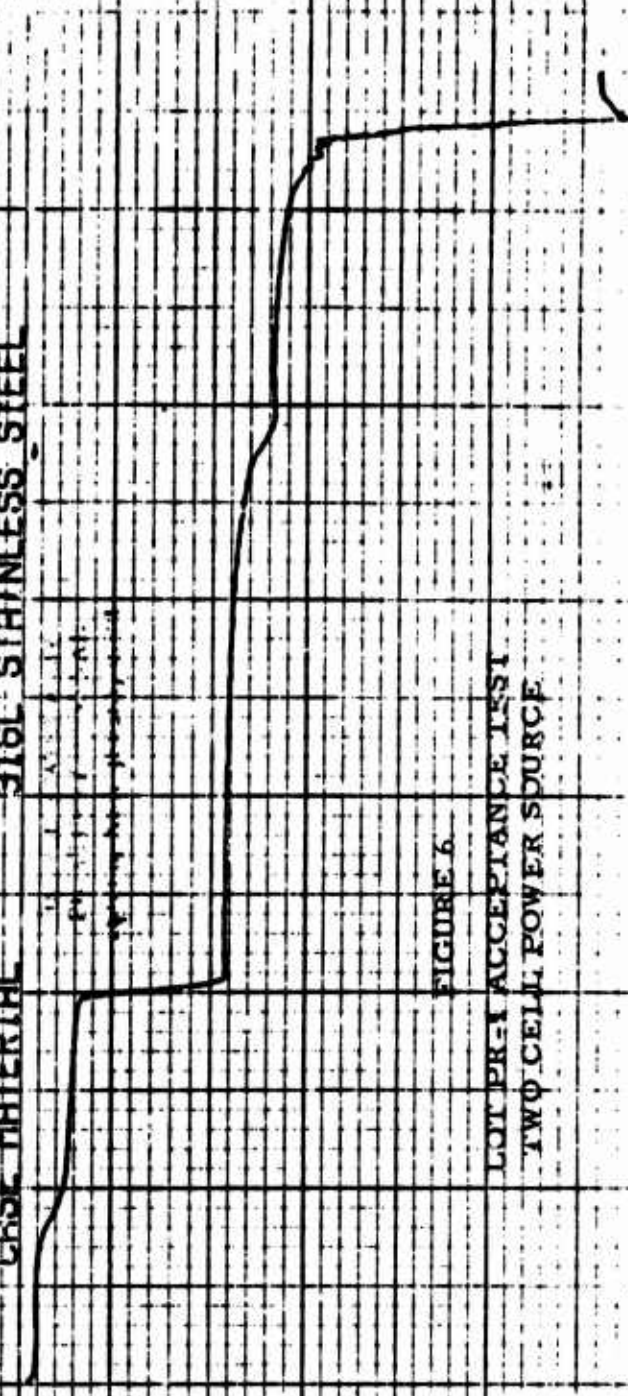
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BATTERY NO. 12

LOAD R (KOHMS) 6.6
TEST TEMPERATURE 135.0 DEGREES F
HONEYWELL 000A21-C-73-0677 S/N 388,317
HOURS TO 5.0 VOLTS 101.5
MA-HR TO 5.0 VOLTS 100.3
AVG VOLTAGE TO 5.0 VOLTS 6.5 VOLTS
AVG CURRENT TO 5.0 VOLTS .99 MA
TEST DATE 010.7/10-24/73

CHEMISTRY LI/LIASF6 LIBF4 MF LI/V205-C
CASE MATERIAL 316L STAINLESS STEEL

EMF (VOLTS)



TIME (HOURS)

BATTERY NO. 13

LOAD R (KOHMS) 6.6

TEST TEMPERATURE 70.0 DEGREES F

HONEYWELL DRAA21-C-73-0677 S/N 401,205

HOURS TO 5.0 VOLTS 0.0

MA-HR TO 5.0 VOLTS 0.0

AVG VOLTAGE TO 5.0 VOLTS 0.0 VOLTS

AVG CURRENT TO 5.0 VOLTS 0.00 MA

TEST DATE 010.7/10-24/73

CHEMISTRY LI/LIASF6 LIBF4 MF LI/V2O5-C

CASE MATERIAL 316L STAINLESS STEEL

FIGURE 7

LOT PH-1 ACCEPTANCE TEST
TWO CELL POWER SOURCE

FIGURE 7

LOT PH-1 ACCEPTANCE TEST
TWO CELL POWER SOURCE

TIME (HOURS)

Chart provided by Picatinny Arsenal

12.00

10.00

1.00

5.00

4.00

2.00

0

-50.00

0

50.00

100.00

150.00

200.00

250.00

300.00

350.00

EMF (VOLTS)

4.0 LOT PR-2

4.1 Seal Development

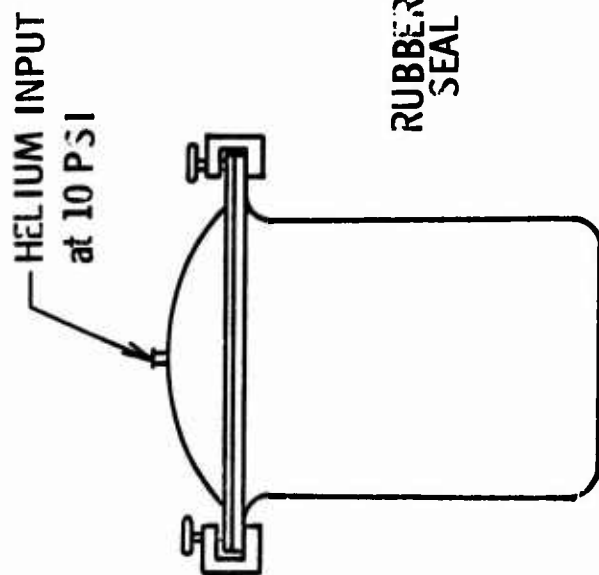
4.1.1 Subsequent to the fabrication and delivery of the 380 units comprising Lot PR-1, a total of 450 additional units were assembled to meet the delivery commitment of 420 units required for Lot PR-2.

4.1.2 During final inspection of Lot PR-2, a substantial quantity of units were rejected because of leakage at the final assembly. These units leaked, while undergoing the seal check per MIL-STD-2020, Method 112A, Condition C, Procedure IIIa. This is a test that requires an external pressurization of the cells with helium gas followed by a detection scan under vacuum with a standard leak detector (mass spectrometer). Figure 8 shows the steps in this leak check process. An additional leak check described as a gross leak check is presented in Figure 9. This gross leak test typically picks up larger leaks in the cell case or electron beam weld area around the terminal plate outside diameter.

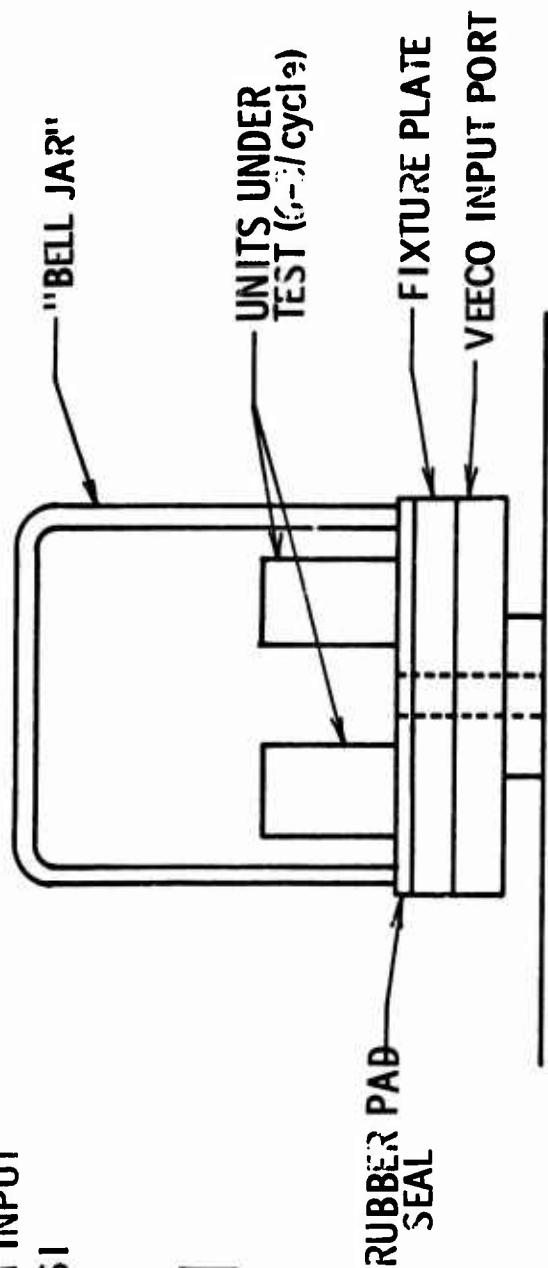
4.1.3 Because of the number of units that failed the fine leak check, the yield of acceptable units from Lot PR-2 was only 218 units. These units were treated as a reduced lot submission, with the balance of the lot to be made up in a subsequent delivery.

4.1.4 The results of the above inspection, in addition to some process duplication work, indicated the following:

- (1) The leaks were occurring at the glass-to-metal negative terminal seal.



STEP 1
PRESSURIZE
(10 PSI Helium for 1 hr min)



STEP 2
LEAK CHECK
(5 min. minimum evacuation
time)

FIGURE 8
"FINE LEAK" CHECK

(MIL-STD-883C, Method 112A, Condition C, Procedure 111a)

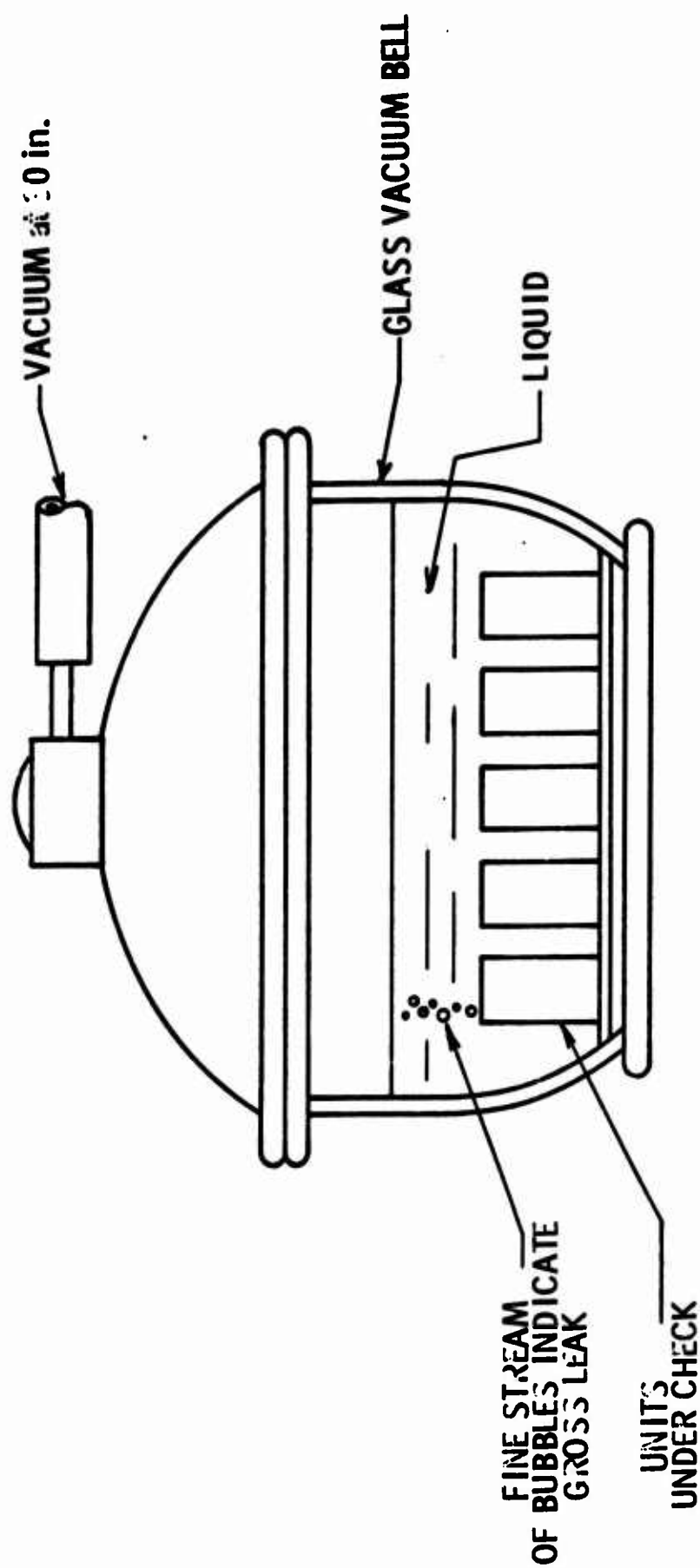


FIGURE 9

GROSS LEAK CHECK

(MIL-STD-202D, Method 112A, Condition B)

- (2) The leaks were only occurring in seals made by one vendor, Northeast Electronics, Lot 06283-1. (The lot also contained seals from Haledone Industries-Seal-A-Metic.)
- (3) The leaks were occurring after the cells were final sealed by electron beam welding.

4.1.5 The last item was determined by taking seals from each vendor and submitting them to each process step encountered during cell fabrication. Before and after each step, leak checks were performed to identify if that particular step caused a problem. Table 2 shows the sequence used in the evaluation of these seven samples, and Figure 10 schematically shows the method of leak checking the terminal plate assembly upon receipt from the vendor. The piece part leak check shown was employed again, after each process cycle as outlined in the sequence up until the samples were electron beam welded, with no leakage being observed. The samples were then divided into two groups as shown in the attached process sequence. Figure 11 shows the test set up used to evaluate four units in the sample by drilling small diameter holes in the base of the cell and using the leak test equipment in conjunction with a helium supply "sniffer." This method permits better location of the fine leak. The remaining three sample units were all from Northeast Electronics and they were leak checked in the bomb test fixture shown in Figure 8.

4.1.6 After electron beam welding, it was determined that every Northeast seal in the test (6) developed a leak. These data, plus the fact that every one of the cells rejected due to leakage was with a Northeast seal compared to none in a group of 160 Seal-A-Metic seals, led to the conclusion that the Northeast seal was the problem area.

TABLE 2

EVALUATION SEQUENCE FOR TERMINAL GLASS SEALS

- 7 Samples - 1 Seal-A-Metic
6 Northeast

STEPS

- Leak check
 - Weld internal lead
 - Leak check
 - Remove lead (tear)
 - Leak check
 - Weld internal lead
 - Leak check
 - EB Weld headers into cases
 - Small hole drilled in base
 - Leak test
 - N/ E - 3 leaks
 - Bomb test 3 N/E
 - Leak detected in all 3
- Seal-A-Metic - passed

TOTAL LOT PR-2

Northeast	168 Fine leaks from 290 sample
	46 Gross
Seal-A-Metic	0 leaks from 160 sample

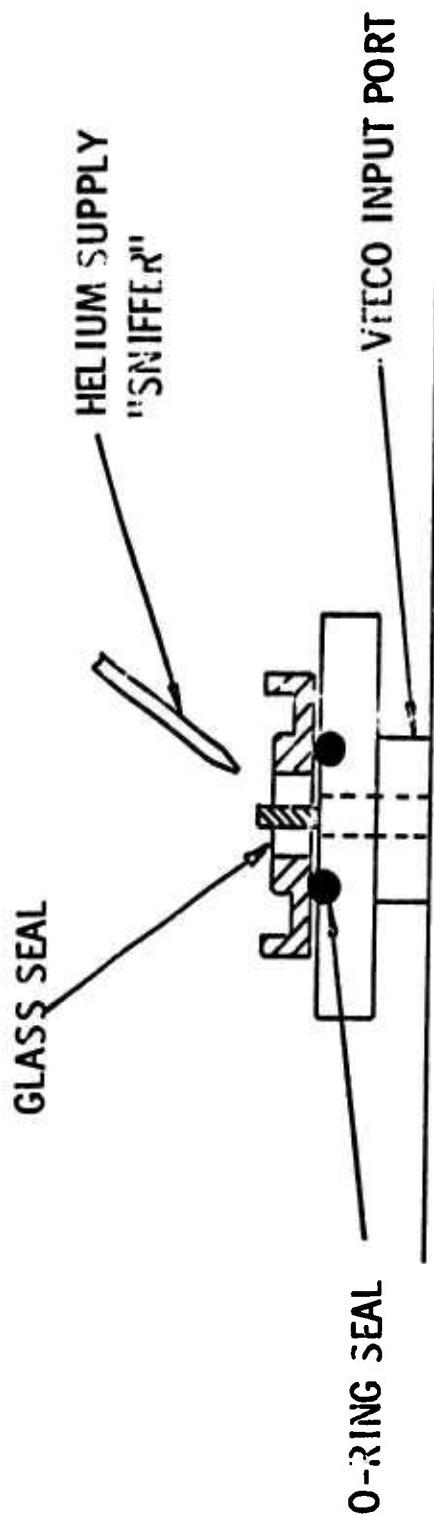


FIGURE 10
PIECE PART LEAK CHECK

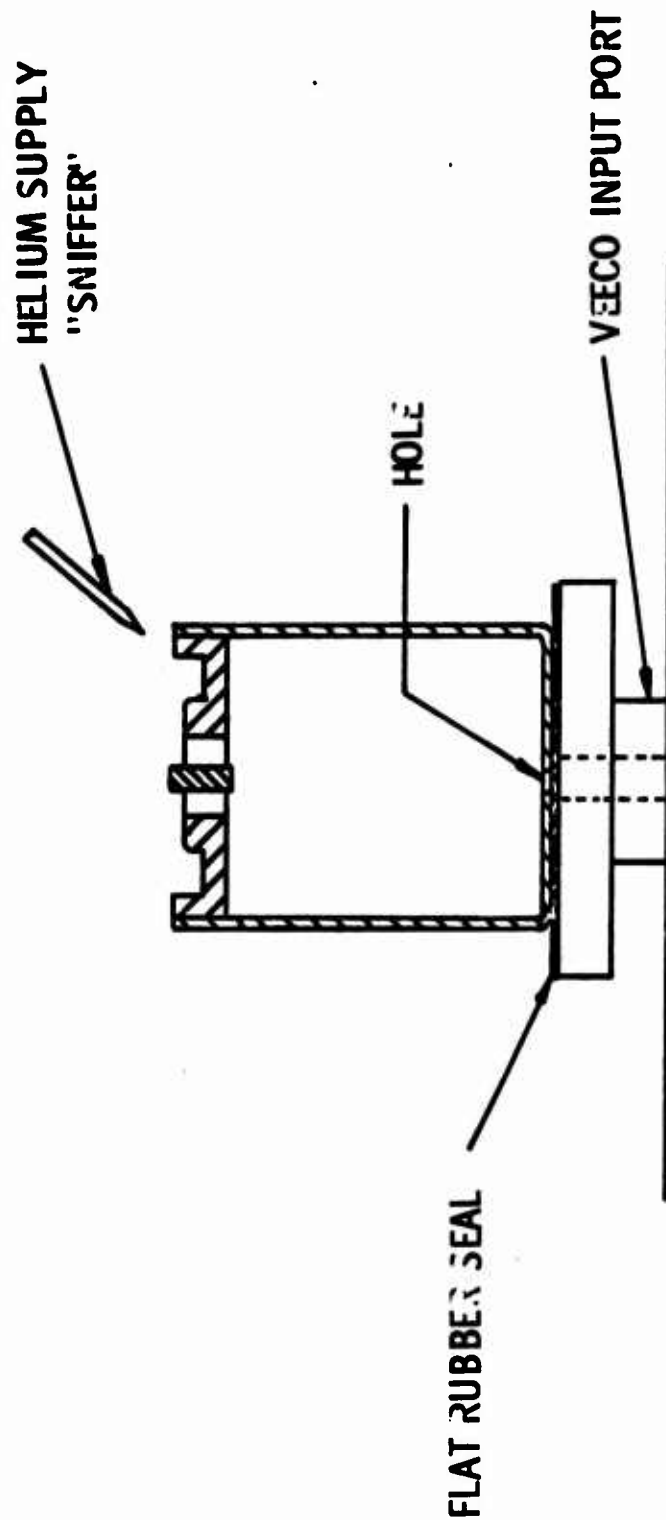


FIGURE 11
ALTERNATE LEAK CHECK OF WELDED TEST UNITS

- 4.1.7 The inspection records and the process tests described above showed that the seals had no leaks up to the electron beam process; however, during welding, the majority of them developed leaks.
- 4.1.8 Seals from Northeast Electronics Corporation were used in Lot PR-2 because the former vendor, Seal-A-Metic had discontinued the manufacture of glass-to-metal seals.
- 4.1.9 A detailed description of the sealing process employed by Seal-A-Metic was obtained, and compared to that which was in use by Northeast Electronics. Three basic process differences were noted, these were:
- (1) Seal-A-Metic used a sandwich fixture to seal; Northeast Electronics used an open fixture.
 - (2) Seal-A-Metic performed a light HCl etch of all metal parts while Northeast did not do this.
 - (3) Seal-A-Metic filled the entire volume of the hole within the terminal plate with glass while Northeast filled all except the slight chamfer in the plate.
- 4.1.10 Extensive work was then carried out with Northeast Electronics to determine the causes and the corrective measures necessary to improve the seal.
- 4.1.11 A review of their inspection procedures and manual found them satisfactory. Completed units were leak checked at 0.65% AQ L. If any leaks were discovered in the sample, the units were 100% leak checked. Dimensional and visual inspections were conducted in the same manner.

- 4.1.12 Figure 12 depicts the differences between the open fixture and the sandwich fixture, Figure 13 is an exaggerated view of the terminal pin before and after etching, while Figure 14 shows differences in the seal configuration due to filling or not filling the terminal plate counter-sink with glass.

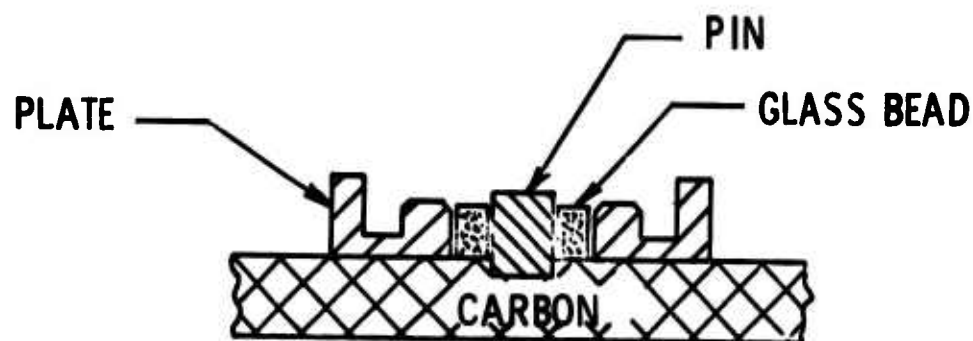
- 4.1.13 A series of four additional generations of seals were then fabricated by Northeast Electronics and tested at Honeywell prior to correcting the seal leakage problem. A description of this work is outlined below and summarized in Table 3.

- 4.1.14 The second generation of seals from Northeast Electronics was received on 10 August 1973. Three groups of these units were prepared using their process, but with the following modifications.

- 4.1.15 All three groups were sealed using a sandwich fixture and all three groups had terminal pins which were previously etched using a 50% HCl solution. Group 1 contained additional glass over the original bead quantity. This glass was added by grinding the beads to provide additional weight. Group 2 also had additional glass and were sandblasted to remove glass splatter from the metal plate. Group 3 used the original bead but was not sandblasted.

- 4.1.16 Table 3 shows the matrix of the sample groups and the reject rates associated with each of them.

- 4.1.17 Evaluation of these three groups showed that the processing changes did not produce a good seal. Seals were leak checked before and after machining of the perimeter with no leaks found. Bomb test and direct



OPEN
FIXTURE



SANDWICH
FIXTURE

FIGURE 12
GLASS SEAL FIXTURING

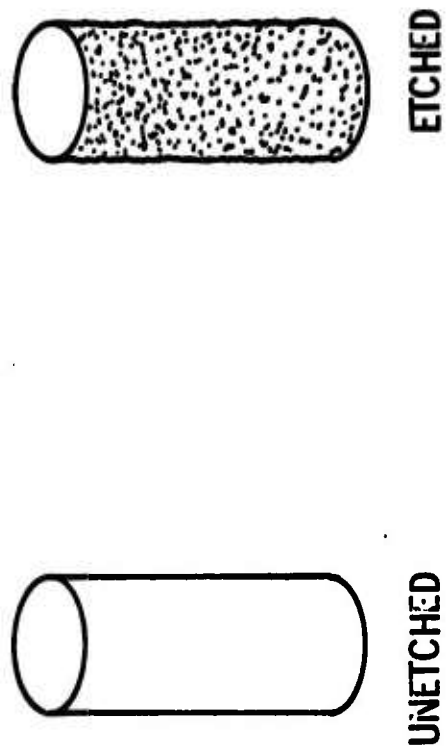
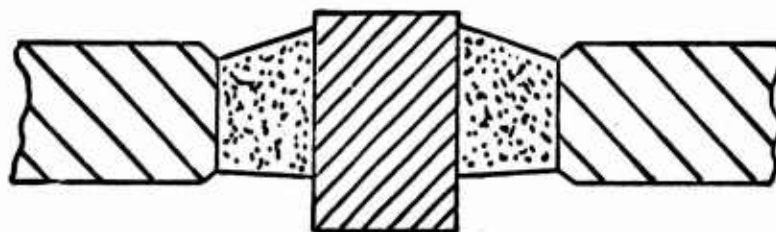
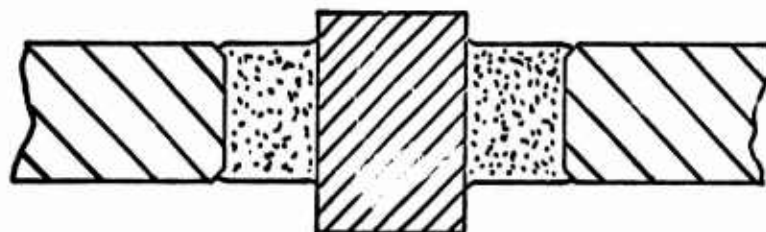


FIGURE 13
TERMINAL PIN - EFFECT OF ETCHING



1



2

FIGURE 14
COMPARISON OF GLASS FILL

TABLE 3
NORTHEAST ELECTRONICS
GLASS SEAL SAMPLE EVALUATION

	2nd Generation Seal						3rd Generation Seal		4th Generation Seal						5th Generation Seal	
	Group Designation						Group Designation		Group Designation							
	1	2	3	A	B	C	AA	BA	DA	EA	FA	GA	H	J		
Sandwich Fixture	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Etched Pins	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Additional Glass	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Blasted	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Larger Bead	--	--	--	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Regular Post Clean	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
No Post Clean	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Reamed Hole	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Etched Plates	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Vacuum Anneal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Post Anneal Clean	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Materials:	316L 9010	316L	316L	316L	316L	316L	316L	304 9010	316L 9010	304 9010	316L	304 9010	316L 5R-MK	304	316L High Strength Glass	4*
Reject Rate (%)	44	100	100	37	75	25	58	83	83	75	100	100	33	0		

*These units were welded using the redesigned heat sink fixture, and out of a lot of 25 units, the one unit that failed the leak test was exposed to four weld passes.

N = No
Y = Yes

leak checks after weld showed leaks in all three groups. The loss rate in Group 1 was slightly lower than those seals previously fabricated by Northeast Electronics and used initially in Lot PR-2; however, it was still far from acceptable.

- 4.1.18 Group 1 had the lowest reject rate at 44%. Group 2 and Group 3 were 100% rejects. Three additional groups of samples were prepared by Northeast Electronics using a solid bead larger than the original glass bead used in the seals. The 316L bodies were unetched, the 52 alloy pins were etched, the sandwich fixture was used as well as a larger bead on all three groups. Group A was processed using the regular post cleaning procedures and resulted in a 37% reject rate. Group B was processed without post cleaning and resulted in a 75% reject rate and Group C had the hole in the plate reamed and used regular post cleaning with a 25% reject rate.
- 4.1.19 Third generation seals were then fabricated. These were received and tested at Honeywell on 21 August 1973. These seals consisted of two groups (Group AA and Group BA) as shown in Table 3. Fifteen parts were included in each group. Group AA was fabricated using 316L stainless steel terminal plates and Group BA was fabricated using 304 stainless steel terminal plates. Both groups of terminal plates were etched at Honeywell in a 50% HCl solution, prior to having the vendor fabricate the glass-to-metal seal. The 304 material was included in these samples, because it was determined that the lot PR-1 seals produced from Seal-A-Metic were made using this material.
- 4.1.20 Initial leak checks performed on both groups before and after machining of the terminal plate O. D. showed that the total of all 30 units passed the leak check; however, after the electron beam welding process, 58% of the 316L terminal plates leaked, and 83% of the 304 terminal plates failed the leak test.

- 4.1.21 Subsequent discussions with Northeast Electronics revealed that the third generation seals discussed above had not been cleaned following annealing, and that they had been annealed in a sealing oven open to the atmosphere. Seal-A-Metic's processing had included annealing the terminal plates in a hydrogen atmosphere which prevented the formation of oxides on the terminal plate. The reason that Northeast Electronics didn't clean the terminal plates associated with the third generation of seals was that they felt the oxides on the terminal plate from the atmospheric annealing process would form a better seal by allowing a bond to the glass as well as a compression seal.
- 4.1.22 For these reasons, fourth generation seals were fabricated in four groups as follows:
- 4.1.23 Group DA and EA consisted of third generation 316L and 304 terminal plates respectively and were sent back to the vendor for post anneal cleaning and resealing. Groups FA and GA also consisted of 316L and 304 material respectively except they were newly etched plates. These plates were vacuum annealed, cleaned after annealing and then sealed. The results of the leak tests associated with each of the above groups of seals in the fourth generation were poor as shown by the reject rate in Table 3.
- 4.1.24 Additional fourth generation seals were fabricated as groups H and J. These groups again used 316L and 304 stainless steel respectively for the terminal plate material. In addition, a high strength glass was used to fabricate the seal. These groups each contained three units; it should be pointed out here, that the sample size (3) in each of these two groups was not large enough to warrant strong conclusions based on the apparent percentage of rejected units. Group H contained (1) leaker out of 3 and Group J contained no leakers out of 3 units.

- 4.1.25 Because of the encouraging results achieved with groups H and J, a fifth generation of seals was fabricated by Northeast Electronics by using high strength glass and 316L stainless steel terminal plates.
- 4.1.26 The initial terminal plates, making up this fifth generation of seals, were received on 3 October 1973, and a total of eight seals were tested after the electron beam welding process. It was found that seven of these units passed the leak test. The eighth unit contained a poor electron beam weld after the first pass with the welder. The unit was then allowed to totally cool down and a second and third pass was made with the electron beam welder in quick succession. This unit subsequently failed to pass the helium leak test. Seven additional terminal plates, fabricated using the same processes as those employed on the previous eight plates, were tested on 10 October 1973, and no leakers were noted. As a result of these tests, an order was placed for a quantity of 1500 glass-to-metal seals fabricated according to the above process.
- 4.1.27 The first quantities of these parts were received on 12 November 1973, and the results of the initial leak check showed that twelve parts out of fifty failed the leak test requirements. At this point, changes were made to the electron beam welding fixture to provide a heat sink to the outer perimeter of the terminal plate and battery case during the welding operation. A sketch of this redesigned heat sink fixture is shown in Appendix C. Parts from the fifth generation of seals were again welded using the reworked welding fixture, and out of a total of 25 additional terminal plate welds, only one unit failed to pass the leak test. This unit was welded with four successive passes and was not allowed to cool down between welds. Because of the above encouraging test results, a decision was made to assemble lot PR-3 using the fifth generation seal design, and the redesigned electron beam welding fixture.

4.2 Quality Control Revisions

4.2.1 As a result of the difficulty encountered with the glass seal in the manufacture of Lot PR-2, a major revision was made to the incoming inspection procedure for the terminal plate assembly.

4.2.2 This was necessary because the procedures at the time of PR-2 manufacture were obviously ineffectual in preventing the use of unsatisfactory seals in final cell assembly. Defective assemblies were identified in final inspection, but at this point each reject represents a significant cost because it is a completed cell. In other words, the inspection system worked in preventing the release of unsatisfactory product, but did so because of the nature of the defect, at a time when the cost impact was too severe.

4.2.3 As discussed above, the fine leaks in the cell were occurring at the terminal plate and were induced by the final sealing operation - the electron beam weld. Up to the welding, marginal seals would not leak and therefore would pass existing inspection requirements.

4.2.4 To identify if incoming seals would fail in final assembly, an inspection procedure was added that required the sampling of ten assemblies from the lot which were then machined and welded into cell cases. The welded "dummy" units were then leak tested with the requirement that all must pass before the balance of the lot is released for cell fabrication. In applying this procedure, a "forward look" is obtained on the ability of the glass seal to withstand the thermal stress of welding. If unsatisfactory, the terminal plate lot is rejected thus precluding the cost of rejecting completed cells.

4.3 Alternate Terminal Seal Vendors

4.3.1 Because of the seal leakage problems that occurred during the build of Lot PR-2, and due to the fact that Northeast Electronics could not duplicate the quality of seal that had originally been provided by Seal-A-Metic, seal development programs were initiated with three new vendors as follows:

(1) Electrical Industries

691 Central Avenue

Murray Hill, N.J. 07974

(2) Mansol Ceramics Company

140 Little Street

Belleville, N.J. 07109

(3) Platronics

320 Colfax Avenue

Clifton, N.J. 07013

4.3.2 Development samples were received from Platronics on a no-charge basis on 19 September 1973. A total of eleven 316L stainless steel terminal plate assemblies were electron beam welded and leak tested. Out of the initial development sample of eleven units, four failed to pass the helium leak tests. It was noted, however, that at least 2 of the above units that were leakers contained 2 weld passes prior to leak testing.

4.3.3 At this point, six of the units from Platronics that were not leakers were put through a reweld cycle on the electron beam welder. Three of these units were put through a single pass reweld cycle, after which

two were discovered to have developed leaks. The remaining three units were put through a double pass reweld cycle, after which one was discovered to have developed a leak.

4.3.4 Subsequent conversations were held with Platronics regarding methods and procedures to improve the quality of the seal, and they expressed a disinterest in proceeding with any additional work on this seal. Therefore, additional development work on the seal was terminated with this vendor.

4.3.5 A purchase order was placed with Mansol Ceramics Corporation to develop the G2666 glass-to-metal seal in 304 and 316L stainless steel plates supplied by Honeywell. Initial prototypes consisting of a sample of eight 304 terminal plates and eight 316L terminal plates were received from Mansol Ceramics on 18 September 1973. From this initial shipment of seals, 3 leakers were discovered when the 304 stainless steel terminal plates were leak checked after electron beam welding and no leakers were observed or found when the 316L stainless steel terminal plates were exposed to the same process and then leak checked. The 316L terminal plates were then divided into two groups of four each for rewelding. The first group of four plates was exposed to a single pass reweld, while the second group of four plates was rewelded with a double pass. Leak checking after welding showed that the single pass reweld units were all good, while the double pass reweld units all leaked.

4.3.6 A larger lot (50 terminal plates) was received from Mansol for evaluation on 8 October 1973. These units were all fabricated using 316L terminal plates and 9010 glass. Leak checking before and after machining the terminal plate O.D. showed no leakage. These units

were then segregated into 3 lots and processed as follows: sixteen units were electron beam welded to empty cases, sixteen units had internal leads welded to the terminal pin and were subsequently electron beam welded to the outer case, and sixteen units had internal leads welded to the terminal pin and were then electron beam welded to cases containing cathodes. After welding, no major differences were noted between the leakage rates of the three groups; the overall leakage rate of these units was 32%.

- 4.3.7 An additional lot of Mansol seals was tested on 14 December 1973 using the redesigned heat sink fixture shown in Appendix C. Twenty-five of these units contained type 79 glass and 22 units were fabricated using type 9010 glass. The results of the leak test performed on these units showed that 96% of the terminal plates with the type 79 glass and 90% of the terminal plates with the 9010 glass passed the test. These test results compare favorably to those achieved with the last submission of Northeast Electronics seals, which were used to fabricate Lot PR-3 cells with the redesigned welding fixture. At this point, based on the above test results, it was felt that Mansol could be considered for future procurement of the G2666 glass-to-metal terminal plate seal.
- 4.3.8 Development work with Electrical Industries was also undertaken to establish an additional source which would be qualified to supply seals for this program. Initially, Honeywell supplied 50 sets of metal parts (per P/N T9275569 and P/N T9275570) to this supplier to fabricate G2666 glass-to-metal seals per P/N T9275603. These parts were fabricated using 9010 glass, 52 alloy pins and 316L stainless steel terminal plates. They were received and tested on 12 December 1973. Initial

leak checks were performed before and after machining of the terminal plate O. D. and no leakers were found. Forty of these units were then electron beam welded to battery cases using the redesigned welding heat sink fixture mentioned earlier. All of the above units passed the fine leak test indicating that Electrical Industries could also be considered as a qualified supplier of G2666 glass-to-metal seals. An additional order for terminal plate assemblies per P/N T9275603 was placed with this vendor which would be kept as Honeywell inventory for future cell manufacture.

4.4 Acceptance Test Results

4.4.1 Thirty-six units were selected for lot acceptance testing by representatives of Picatinny Arsenal out of a lot size of 218 units. As explained previously, this lot size was reduced from 400 units due to the glass-to-metal seal problems. Tests were performed at Picatinny Arsenal with a Honeywell representative in attendance. The pretest preparation and assembly of the units into hardware was carried out as previously explained under the PR-1 lot acceptance test discussion. The eighteen resulting power sources were also subjected to the same test environments as those used earlier for the PR-1 lot acceptance tests. Typical voltage vs. time profiles are shown in Figures 15, 16 and 17. The results indicated that all units tested, with the exception of possibly one, met the required minimum life to five volts.

4.4.2 Figure 18 shows the voltage profile of the unit in question. This unit evidenced voltage fluctuations below five volts during the test period. An investigation to determine the cause of the fluctuations produced no evidence to believe that the cells themselves were responsible for these fluctuations. This conclusion was based upon the results of a

BATTERY NO. 23

LOAD R(KOHMS) 6.6

TEST TEMPERATURE -95.0 DEGREES F

HONEYWELL DAA21-C-73-0677 S/N 678.733

HOURS TO 5.0 VOLTS 89.5

MA-HR TO 5.0 VOLTS 82.9

AVG VOLTAGE TO 5.0 VOLTS 6.1 VOLTS

AVG CURRENT TO 5.0 VOLTS .93 MA

TEST DATE 012.8/13-27/73

CHEMISTRY LI/LIASF6 LIBF4 MF LI/V205-C

CASE MATERIAL 316L STAINLESS STEEL

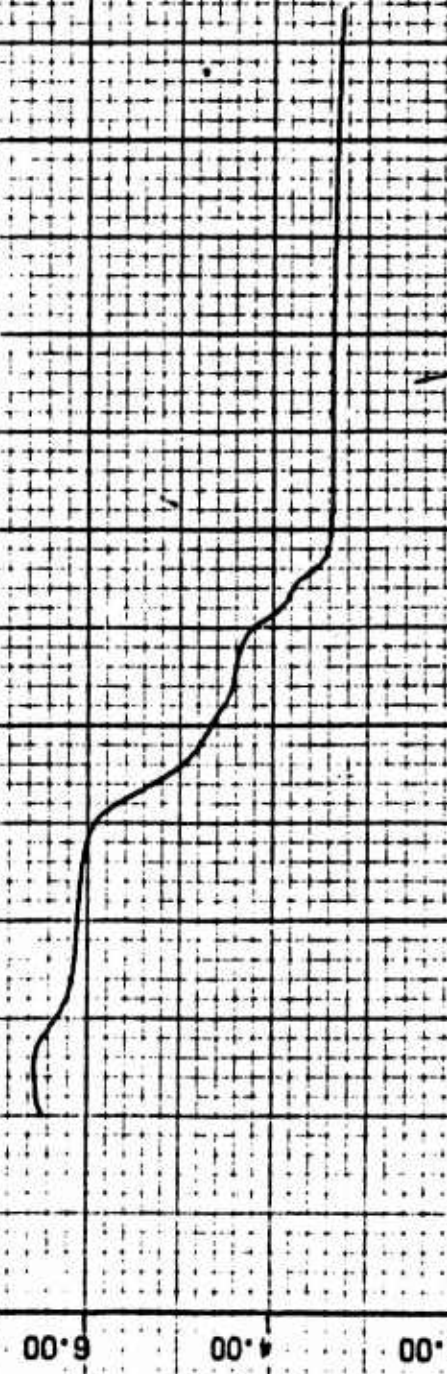


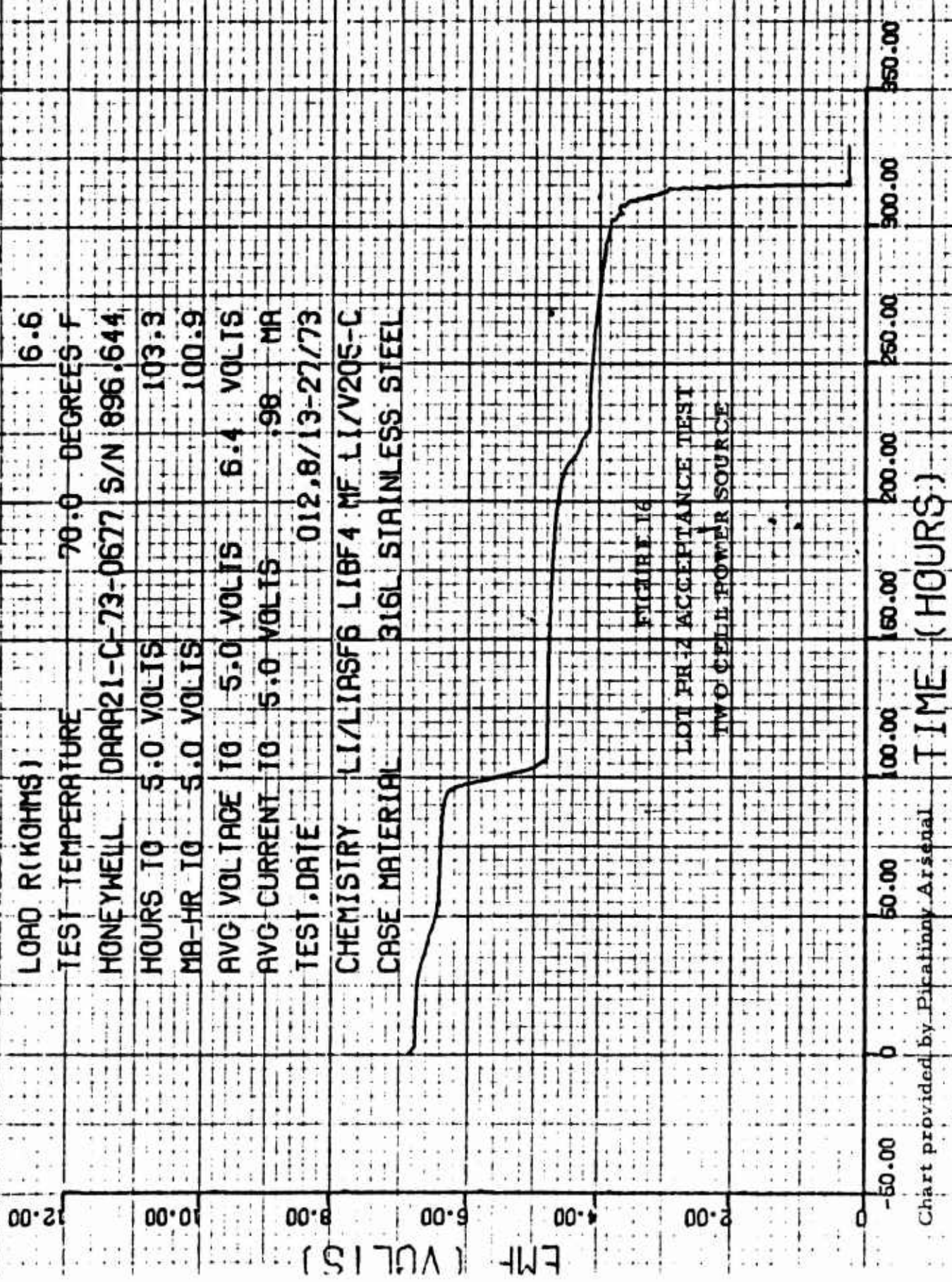
FIGURE 11
LOT PR-2 ACCEPTANCE TEST
TWO CELL POWER SOURCE

Chart provided by Picatinny Arsenal

BATTERY NO. 28

LOAD R (KOHMS) 6.6
 TEST TEMPERATURE 70.0 DEGREES F
 HONEYWELL DARA21-C-73-0677 S/N 896.644
 HOURS TO 5.0 VOLTS 103.3
 MA-HR TO 5.0 VOLTS 100.9
 AVG VOLTAGE TO 5.0 VOLTS 6.4 VOLTS
 AVG CURRENT TO 5.0 VOLTS .98 MA
 TEST DATE 012.8/13-27/73

CHEMISTRY LI/LIASF6 LIBF4 MF LI/V205-C
 CASE MATERIAL 316L STAINLESS STEEL



BATTERY NO.

36

LOAD R (KOHMS)

6.6

TEST TEMPERATURE

135.0 DEGREES F

HONEYWELL

DARA21-C-73-0677 S/N 627,682

HOURS TO

5.0 VOLTS

101.8

MA-HR TO

5.0 VOLTS

100.4

AVG VOLTAGE TO

5.0 VOLTS

6.5 VOLTS

AVG CURRENT TO

5.0 VOLTS

.99 MA

TEST DATE

012.8/13-27/73

CHEMISTRY

LI/LIASF6 LIBF4 MF LI/V205-C

CASE MATERIAL

316L STAINLESS STEEL

12.00

10.00

8.00

6.00

4.00

2.00

0

CELL VOLTAGE

FIGURE 17

LOT PR-2 ACCEPTANCE TEST

TWO ORILL POWER SOURCE

Chart provided by Picatinny Arsenal

50.00

0

50.00

100.00

150.00

200.00

250.00

300.00

350.00

BATTERY NO. 27

LOAD R (KOHMS) 6.6

TEST TEMPERATURE 70.0 DEGREES F

HONEYWELL DAA21-C-73-0677 S/N 732,647

HOURS TO 5.0 VOLTS 22.4

MA-HR TO 5.0 VOLTS 22.6

AVG VOLTAGE TO 5.0 VOLTS 6.7 VOLTS

AVG CURRENT TO 5.0 VOLTS 1.01 MA

TEST DATE 012.8/13-27/73

CHEMISTRY LI/LIASF6 LIBF4 MF LI/V205-C

CASE MATERIAL 316L STAINLESS STEEL

EMF (VOLTS)

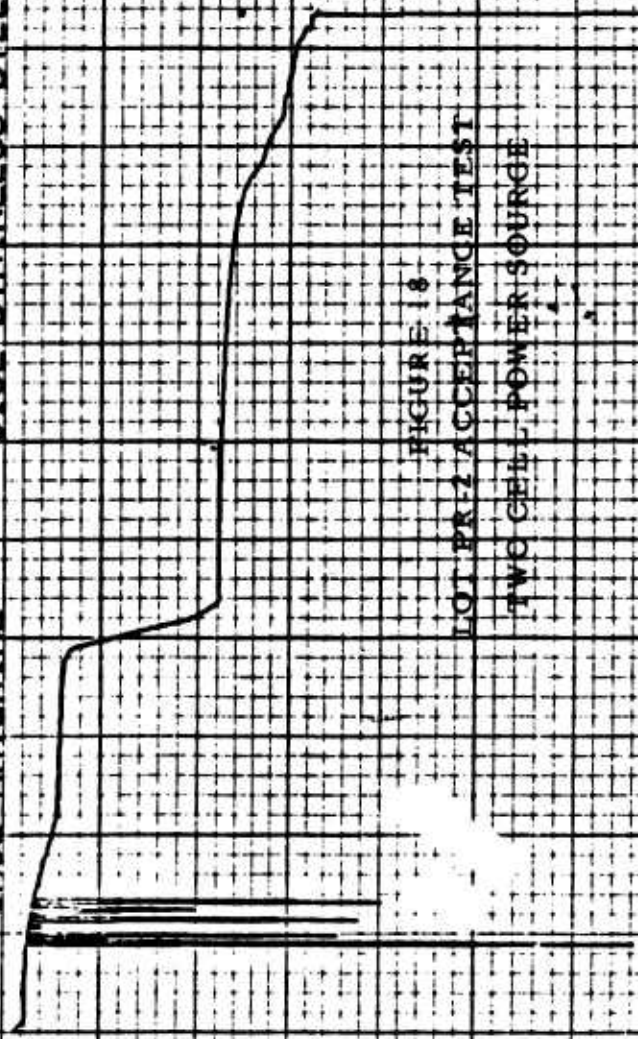


FIGURE 18

LOT PR-2 ACCEPTANCE TEST

TWO CELL POWER SOURCE

TIME (HOURS)

Chart provided by Plootiny Arsenal

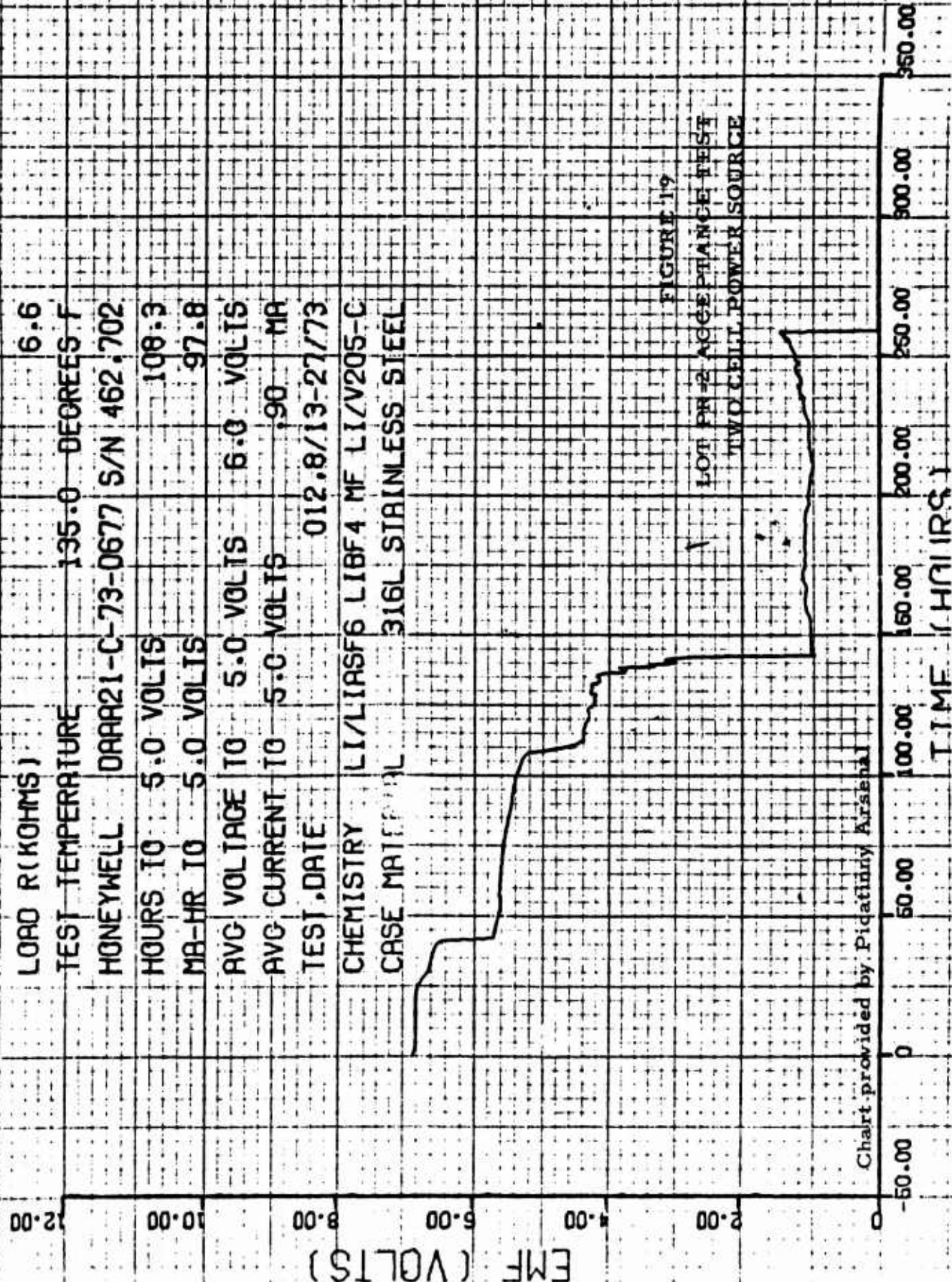
wiring check performed at the time the fluctuations occurred and on a post mortem performed on the cells after the test period. A copy of the post mortem findings associated with this power source (unit number 27 - cells number R-647 and R-732) is included in Appendix A.

- 4.4.3 Figure 19 is a voltage profile of a high temperature test unit (+135°F) from the PR-2 lot acceptance sample that did meet the required minimum life to five volts; however, it's life to 2.5 volts was shorter than that observed in the balance of the lot, as demonstrated by comparing the curves of Figures 17 and 19. This unit contained cells number R-462 and R-702. A post mortem examination of this power source and the cells involved was performed after the test, and no unusual findings were noted, other than higher than normal anode consumption. A copy of the post mortem report on these units is included in Appendix A.
- 4.4.4 As was done with Lot PR-1, data on the bottom case depressions resulting from activation of Lot PR-2 were accumulated. These results are essentially the same as those associated with the testing of Lot PR-1. The average depression in Lot PR-2 was 0.0294 inches, and the comparable number found in Lot PR-1 was 0.035 inches. The case depression data for Lot PR-2 are also included in Appendix A.
- 4.4.5 After a review of the results of the evidence associated with the above power sources, a determination was made by the Mine Branch at Picatinny Arsenal that all the units tested met the acceptance criteria and Lot PR-2 was approved for delivery.
- 4.4.6 The balance of the lot, consisting of one hundred eighty-two units, was shipped to Honeywell, Inc. Ordnance Division, Hopkins, MN 55343.

BATTERY NO. 34

LOAD R (KOHMS) 6.6
 TEST TEMPERATURE 135.0 DEGREES F
 HONEYWELL DARA21-C-73-0677 S/N 462,702
 HOURS TO 5.0 VOLTS 108.3
 MA-HR TO 5.0 VOLTS 97.8
 AVG VOLTAGE TO 5.0 VOLTS 6.0 VOLTS
 AVG CURRENT TO 5.0 VOLTS .90 MA
 TEST DATE 012.8/13-27/73

CHEMISTRY LI/LIASF6 LIBF4 MF LI/V205-C
 CASE MATERIAL 316L STAINLESS STEEL



5.0 LOT PR-3

5.1 Fabrication Program

5.1.1 It will be recalled that shortages in Lot PR-2 were a result of a fine leak problem discovered during the final in-house inspection of the completed cells. Extensive activity with the supplier of the terminal plate assembly resulted in a solution to the fine leak problem, and the terminal plates required to complete the deliveries on the contract were obtained from Northeast Electronics on 12 November 1973. The build of the deliverable hardware was finished during the first week in December. Final in-house inspection of these units showed that less than 4% were rejected due to glass-to-metal seal leakage.

5.1.2 Because of the delivery shortages occurring on Lots PR-1 and PR-2, additional cells were delivered in Lot PR-3. These additional cells changed the lot size from an original requirement of 400 cells to 602 cells. The lot acceptance test sample was in turn proportionally increased from thirty six to fifty four cells.

5.2 Acceptance Testing

5.2.1 Lot acceptance test units were selected by Picatinny Arsenal and these units were transferred to the Arsenal on 3 December 1973. The acceptance sample was tested at Picatinny Arsenal with a Honeywell representative in attendance. Equal numbers were discharged at three environments, (-35°F, 70°F and 135°F) with accept/reject criteria remaining unchanged. The results indicated that all of the units tested met the acceptance requirements contained in Appendix B, Page B1, Paragraph IV of the contract. Pursuant with this result, the Mine Branch determined that Lot PR-3 was acceptable.

5.2.2 Disposition of the remainder of the lot was as follows: four-hundred and twenty-four units were shipped to Honeywell Inc., Ordnance Division, Hopkins, MN 55343 and one-hundred twenty-four cells were shipped to Picatinny Arsenal SARPA-AD-D-M, Dover, New Jersey 07801. Each of the one-hundred twenty-four cells had two, three-inch solderable tabs attached to it, at the request of Picatinny Arsenal.

5.2.3 The results of the lot acceptance testing conducted on the PR-3 units are summarized below:

<u>Temp. °F</u>	<u>No. of Power Sources</u>	<u>Average Hours to 5.0 volts</u>	<u>Average Hours to 4.0 volts</u>
+135	9	102.2	301.4
+70	9	107.3	289.3
-35	9	91.8	134.7

5.2.4 These cells all ran very good and were very consistent. The curves presented in Figures 20, 21 and 22 are typical of the results obtained at each test temperature. The lowest life obtained was for unit number 3 shown in Figure 22. This unit ran for 85 hours to the five volt level and 215 hours to the four volt level at a test temperature of +135°F. The balance of the units tested were tightly grouped about the averages shown above.

5.2.5 Case depression data were again accumulated on the lot acceptance test units, after their return to Honeywell, and are included in Appendix A. The results of work showed that the average case depression in Lot PR-3 was 0.024 inch. The grouping range or spread of the case depression data on this lot of units was far more

11

6.71

35.0 DEGREES F

1166.1479

91.5

83.6

6.1 VOLTS

.91 MA

013.12/13-28/73

CHEMISTRY LI/LIASFC LIBF4 MF LI/V205-C

CASE MATERIAL 316L STAINLESS STEEL

FIGURE 20

LOT PR-3 ACCEPTANCE TEST

TWO CELL POWER SOURCE

EMF (VOLTS)

350.0

250.0

150.0

50.0

TIME (HOURS)

BATTERY NO. 25

LOAD R (KOHMS) 6.67

TEST TEMPERATURE 70.0 DEGREES F

HONEYWELL DAA21-C-73-0677 S/N 1274.1051

HOURS TO 5.0 VOLTS 106.0

MA-HR TO 5.0 VOLTS 102.9

AVG VOLTAGE TO 5.0 VOLTS 6.5 VOLTS

AVG CURRENT TO 5.0 VOLTS .97 MA

TEST DATE 013, 12/13-28/73

CHEMISTRY LI/LIASF6 LIBF4 ME LI/V205-C

CASE MATERIAL 316L STAINLESS STEEL

12.0

EMF (VOLTS)

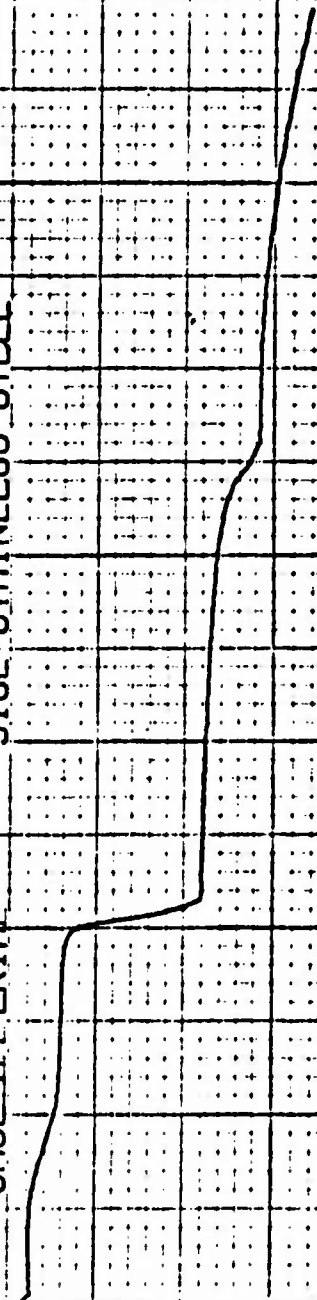


FIGURE 21

LPT PR-3 ACCEPTANCE TEST
TWO CELL POWER SOURCE

-50.0

50.0

150.0

250.0

350.0

TIME (HOURS)

BATTERY NO.

3

LOAD R(KOHMS)

6.73

TEST TEMPERATURE

135.0 DEGREES F

HONEYWELL DATA21-C-73-0677 S/N 1342.1473

HOURS TO 5.0 VOLTS

85.5

MA-HR TO 5.0 VOLTS

82.3

AVG VOLTAGE TO 5.0 VOLTS

6.5 VOLTS

AVG CURRENT TO 5.0 VOLTS

.96 MA

TEST DATE

013, 12/13-28/73

CHEMISTRY LI/LIASF6 LIBF4 MF LI/V205-C

CASE MATERIAL 316L STAINLESS STEEL

12.0

8.0

EMF (VOLTS)

4.0

0

50.0

50.0

150.0

250.0

350.0

TIME (HOURS)

FIGURE 22

LOT PR-3 ACCEPTANCE TEST
TWO CELL POWER SOURCE

consistent than that previously obtained on Lots PR-1 and PR-2. The maximum depression observed in Lot PR-3 was 0.035 inch, and a minimum depression of 0.016 inch was recorded. Similar respective numbers were 0.051 and 0.014 inch for Lot PR-2 and 0.069 and 0.013 inch for Lot PR-1.

6.0 MISCELLANEOUS XM70 CELL TESTING

6.1 During the manufacture of the deliverable items required under this contract, generation of various types of inspection rejects, plus over-build of acceptable units occurred. A summary of these cells is provided in Table 4. Over the course of the contract, 40 cells from the fine leak category were tested in an environmental test program designed to determine the effect of this defect on performance after storage under various conditions.

6.2 The test matrix employed in the evaluation of these 40 units is outlined below:

- (1) 8 baseline units were discharged at the start of the test.
 - 4 were preconditioned and tested at +135°F
 - 4 were preconditioned and tested at -35°F
- (2) 16 units were discharged after T and H storage
 - 4 were tested at +135°F after 2 weeks storage
 - 4 were tested at -35°F after 2 weeks storage
 - 4 were tested at +135°F after 4 weeks storage
 - 4 were tested at -35°F after 4 weeks storage
- (3) 8 units were discharged after 30 days storage at +160°F.
 - 4 were tested at +135°F
 - 4 were tested at -35°F
- (4) 8 units were discharged after 30 day storage at -65°F
 - 4 were tested at +135°F
 - 4 were tested at -35°F

TABLE 4

RESIDUAL INVENTORYG2666 CELLS - CONTRACT DAAA21-73-C-0677

<u>LOT</u>	<u>QUANTITY</u>	<u>COMMENT</u>
PR-1	20	Anode Lead Rejects
PR-2	118	Fine Leak
	4	Anode Lead Reject
	3	Fine Leak and Anode Lead Reject
PR-3	32	Acceptable Units
	26	Fine Leak
	3	Marginal Anode Lead

- 6.3 All units were activated with piston activators and discharged under a 3.25K ohm load. A summary of the test results is presented in Table 5.
- 6.4 Generally, the output of the cells was unaffected by the environmental storage conditions. A very slight decrease in the average active life of the cells was noted, when tested at low temperature after being stored at high temperature. For example, after 30 days storage at +160°F, the average active life of units tested at -35°F was 88.0 hours, compared to 90.8 hours to a 2.5 volt cutoff. A slightly greater effect on the average active life of cells stored in a T and H environment or a constant high temperature environment (+160°F) was noted to a 2.0 volt cutoff when these cells were discharged at +135°F. This trend can be seen by noting that after 14 days of T and H storage, cells discharged at +135°F operated for an average active life of 248.3 hours vs. 262 hours associated with the baseline cells that were not exposed to any storage environments.
- 6.5 However, under cold temperature storage conditions, the above effects were not noted. Cells tested at +135°F, after being stored 30 days at -65°F, operated for an average active life of 272.5 hours to a 2.0 volt cutoff, compared to 262 hours for the baseline cells.
- 6.6 By observing the voltage data generated, when cells from the longest (30 day) T and H storage units were discharged at low temperature (-35°F), it will be noted that the average voltage decreased 0.05 volt from that which was observed with the baseline cells to a 2.5 volt cutoff. This was the highest change for this value in all groups tested. Reading similar values to the 2.0 volt cutoff shows that the same indication is apparent.

A

TABLE 5
DISCHARGE DATA
ENVIRONMENTAL TEST PLAN - FINE LINE
LOAD 3.25K ohms - G26

Cell Group	Cell No.	Storage Time (days)	Test Temp.	Discharge Time to 2.5V	% Cathode Efficiency to 2.5V	Discharge Time to 2.0V	% Cathode Efficiency to 2.0V	Avg. Voltage ²		A
								2.5V	2.0V	
<u>Baseline Cells</u>	513	none	+135°F	99.0	94.0	262.0	210.7	3.27	2.74	1.0
	604			102.0	98.2	282.0	222.6	3.28	2.69	1.0
	551			102.0	97.5	206.0	175.5	3.27	2.90	1.0
	881			104.0	95.6	240.0	233.4	3.23	2.67	1.0
	<u>Average</u>			101.0	96.4	247.0	210.5	3.26	2.75	1.0
<u>T and H Storage Cells</u>	503	14	-35°F	91.0	81.5	127.0	105.5	3.07	2.63	1.0
	846			91.0	83.3	140.0	117.4	3.12	2.56	1.0
	873			90.0	82.4	129.0	109.5	3.12	2.59	1.0
	562			91.0	83.1	134.0	113.5	3.11	2.58	1.0
	<u>Average</u>			90.8	82.1	132.5	111.5	3.10	2.58	1.0
<u>T and H Storage Cells</u>	560	14	+135°F	81.0	76.0	215.0	172.0	3.20	2.73	1.0
	852			99.0	94.1	275.0	217.2	3.24	2.69	1.0
	897			95.0	93.0	247.0	223.7	3.27	2.66	1.0
	610			99.0	94.0	219.0	171.5	3.27	2.71	1.0
	<u>Average</u>			94.0	89.3	244.3	196.2	3.24	2.70	1.0
<u>T and H Storage Cells</u>	472	14	-35°F	96.0	86.2	129.0	108.1	3.06	2.57	1.0
	490			96.0	87.1	123.0	104.1	3.09	2.54	1.0
	523			95.0	86.5	115.0	99.3	3.10	2.42	1.0
	554			96.0	87.2	123.0	110.3	3.10	2.52	1.0
	<u>Average</u>			95.8	86.8	122.3	105.5	3.09	2.53	1.0
<u>T and H Storage Cells</u>	775	28	+135°F	93.0	94.1	240.0	219.4	3.27	2.70	1.0
	608			101.0	97.5	221.0	181.1	3.29	2.61	1.0
	561			99.0	94.4	235.0	185.6	3.25	2.71	1.0
	612			98.0	93.1	210.0	176.9	3.23	2.77	1.0
	<u>Average</u>			98.0	94.8	226.5	189.5	3.25	2.70	1.0
<u>T and H Storage Cells</u>	491	28	-35°F	95.0	86.7	129.0	109.3	3.05	2.56	1.0
	865			93.0	83.8	132.0	110.4	3.07	2.55	1.0
	568			87.0	78.5	132.0	103.5	3.07	2.50	1.0
	755			90.0	80.3	133.0	101.3	3.04	2.50	1.0
	<u>Average</u>			91.3	82.3	131.5	106.7	3.05	2.53	1.0

¹100% efficiency = 1 Faraday per mole of cathode oxidant.

²Integrated value for entire active life up to the indicated voltage level.

³Energy Density values on basis of total cell volume of 0.162 in³ and average total cell

TABLE 5

DISCHARGE DATA

B

TEST PLAN - FINE LEAK INSPECTION REJECTS

D 3.25K ohms - G2000 CELL

Code Qty	Avg. Voltage ²		Avg. Current (mA)		Capacity (mAhrs)		Avg. Power (mW)		Energy (mWhrs)		Whrs/in ³		Whrs/lb ³	
	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V
7	3.27	2.74	1.01	.84	100.0	220.1	3.30	2.30	327	603	2.02	3.72	25.9	47.8
6	3.28	2.69	1.01	.83	103.0	234.1	3.31	2.23	338	630	2.09	3.89	26.8	50.0
5	3.27	2.90	1.01	.89	103.0	183.3	3.30	2.58	337	531	2.08	3.28	26.7	42.1
4	3.23	2.67	.99	.82	103.0	244.4	3.20	2.19	333	652	2.05	4.03	26.4	51.7
5	3.26	2.75	1.00	.84	103.3	220.5	3.27	2.32	333.8	604	2.06	3.73	26.5	47.9
6	3.07	2.63	.94	.87	85.5	110.5	2.89	2.46	263	312	1.62	1.93	20.9	24.7
4	3.12	2.66	.96	.86	87.4	123.2	3.00	2.52	273	352	1.68	2.18	21.6	27.9
5	3.12	2.89	.96	.89	86.4	114.8	3.00	2.57	270	332	1.66	2.05	21.4	26.3
5	3.11	2.88	.95	.86	87.4	119.3	2.99	2.57	272	345	1.68	2.13	21.6	27.4
5	3.10	2.86	.95	.85	86.7	116.9	2.97	2.55	269.5	335.3	1.66	2.07	21.4	26.6
0	3.20	2.73	.99	.84	79.4	180.6	3.14	2.29	254	493	1.57	3.04	20.1	39.1
2	3.24	2.69	1.00	.83	99.0	228.3	3.24	2.23	321	614	1.98	3.79	25.5	48.7
7	3.27	2.66	1.01	.92	99.0	235.3	3.30	2.18	324	628	2.00	3.86	25.7	49.6
8	3.27	2.71	1.01	.83	92.0	178.3	3.30	2.25	324	487	2.00	3.00	25.7	38.5
2	3.24	2.66	1.00	.83	94.1	206.2	3.24	2.23	321.2	554.2	1.98	3.42	24.3	44.0
1	3.06	2.66	.94	.88	90.2	113.5	2.86	2.52	270	325	1.70	2.00	21.9	25.8
1	3.09	2.65	.95	.89	91.2	109.5	2.94	2.56	272	315	1.74	1.95	22.4	25.0
3	3.10	2.62	.95	.90	92.3	104.4	2.95	2.63	270	305	1.73	1.88	22.2	24.2
3	3.10	2.62	.95	.90	91.2	110.1	2.95	2.63	273	339	1.75	2.09	22.4	26.9
5	3.15	2.66	.96	.89	91.7	110.9	2.98	2.58	277	321	1.72	1.95	22.2	25.5
4	3.26	2.67	1.00	.82	99.0	223.6	3.26	2.19	327	613	1.99	3.71	25.6	48.6
1	3.29	2.61	1.01	.96	102.0	189.2	3.32	2.42	336	532	2.07	3.28	26.6	42.2
6	3.25	2.71	1.00	.83	98.0	196.1	3.25	2.35	327	529	1.99	3.21	25.5	42.0
9	3.23	2.77	.99	.85	87.1	118.5	3.20	2.35	271	494	1.79	3.04	22.3	39.2
5	3.25	2.68	1.00	.84	91.5	110.1	3.25	2.35	272.5	522	1.79	3.04	22.3	39.2
5	3.05	2.64	.94	.85	82.7	112.1	2.87	2.64	262	309	1.56	1.99	20.6	24.5
4	3.07	2.65	.94	.88	87.4	116.2	2.89	2.61	268	331	1.66	2.04	21.3	26.2
5	3.07	2.60	.94	.86	81.8	113.5	2.89	2.41	261	318	1.58	1.96	19.9	25.2
3	3.04	2.61	.94	.86	84.6	114.4	2.86	2.41	267	301	1.59	1.98	20.4	25.5
7	3.05	2.60	.94	.86	84.1	114.1	2.87	2.41	267.4	301.4	1.59	1.97	20.4	25.4

level.

and average total cell weight of 5.72 grams.

TABLE 5 (CONTIN

Cell Group	Cell No.	Storage Time (days)	Test Temp.	Discharge Time to 2.5 V	% Cathode Efficiency to 2.5 V	Discharge Time to 2.0 V	% Cathode Efficiency ¹ to 2.0 V	Avg. Voltage ²	
								2.5 V	2.0 V
<u>High Temp. Storage Cells</u> <u>+160°F</u>	572	30	+135°F	90.0	83.8	240.0	189.3	3.18	2.60
	855			100.0	96.0	265.0	213.1	3.27	2.74
	496			80.0	74.4	193.0	153.2	3.17	2.71
	866			101.0	96.5	292.0	228.1	3.26	2.66
<u>Average</u>				92.8	87.7	247.5	195.9	3.22	2.70
	810		-35°F	92.0	84.1	129.0	108.6	3.12	2.57
	837			92.0	82.5	131.0	107.2	3.06	2.79
	845			82.0	74.3	117.0	96.1	3.09	2.80
	485			86.0	78.2	123.0	101.7	3.10	2.92
<u>Average</u>				88.0	79.8	125.0	103.4	3.09	2.82
<u>Low Temp. Storage Cells</u> <u>-65°F</u>	784	30	+135°F	102.0	97.4	295.0	229.7	3.26	2.65
	597			99.0	94.6	283.0	222.1	3.26	2.68
	824			103.0	96.6	293.0	229.3	3.26	2.67
	481			88.0	82.0	219.0	176.2	3.18	2.74
<u>Average</u>				98.0	92.7	272.5	214.3	3.22	2.74
	539		F	90.0	81.3	127.0	106.1	3.05	2.55
	806			90.0	81.9	137.0	113.1	3.10	2.82
	492			89.0	81.3	124.0	104.1	3.12	2.86
	575			85.0	75.7	120.0	103.5	3.04	2.87
<u>Average</u>				85.5	80.1	125.5	106.7	3.08	2.83

¹100% efficiency = 1 Faraday per mole of cathode oxidant.

²Integrated value for entire active life up to the indicated voltage level.

³Energy Density values on basis of total cell volume of 0.162 in³ and average total c

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TABLE 5 (CONTINUED)

Node Frequency ¹ 0V	Avg. Voltage ²		Avg. Current (mA)		Capacity (mAhrs)		Avg. Power (mW)		Energy (mWhrs)		³ Whrs/in ³		Whrs/lb ³	
	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V
9.3	3.18	2.60	.98	.83	88.2	199.2	3.12	2.23	280	536	1.73	3.31	22.2	42.5
3.1	3.27	2.74	1.01	.84	101.0	222.6	3.30	2.31	330	610	2.04	3.76	26.2	48.4
3.2	3.17	2.71	.98	.83	78.4	160.2	3.11	2.25	249	434	1.53	2.68	19.7	34.4
8.1	3.26	2.66	1.00	.82	101.0	239.4	3.26	2.18	329	637	2.03	3.93	26.1	50.5
5.9	3.22	2.70	.99	.83	92.2	186.4	3.19	2.24	297	554.3	1.83	3.42	23.6	44.0
8.6	3.12	2.57	.96	.88	88.3	113.5	3.00	2.53	276	326	1.70	2.01	21.9	25.9
7.2	3.06	2.79	.94	.86	86.5	112.7	2.88	2.40	265	314	1.63	1.94	20.6	24.9
6.1	3.09	2.80	.95	.86	77.9	100.6	2.94	2.41	241	282	1.49	1.74	19.1	22.4
1.7	3.10	2.82	.95	.87	81.7	107.0	2.95	2.45	253	302	1.56	1.86	20.1	23.9
3.4	3.09	2.82	.95	.86	83.6	108.5	2.94	2.44	258.8	306	1.59	1.88	20.4	24.3
9.7	3.26	2.65	1.00	.82	102.0	241.9	3.26	2.17	333	641	2.05	3.96	26.4	50.8
2.1	3.26	2.68	1.00	.82	99.0	232.1	3.26	2.20	323	622	1.99	3.84	25.6	49.3
9.3	3.20	2.67	.98	.82	100.9	240.3	3.14	2.19	323	641	1.99	3.96	25.6	50.8
6.2	3.18	2.74	.98	.84	86.2	184.0	3.12	2.30	274	504	1.69	3.11	21.7	40.0
4.3	3.22	2.85	.99	.82	97.0	224.6	3.19	2.21	313.3	602	1.93	3.71	24.8	47.7
6.1	3.08	2.85	.95	.88	85.5	111.8	2.93	2.51	263	319	1.63	1.97	20.9	25.3
3.1	3.10	2.82	.95	.87	85.5	119.2	2.95	2.45	265	336	1.64	2.07	21.0	26.6
4.1	3.12	2.86	.96	.88	85.4	109.1	3.00	2.52	267	312	1.65	1.93	21.2	24.7
3.5	3.04	2.80	.94	.86	79.0	108.4	2.85	2.41	243	303	1.50	1.87	19.3	24.0
6.7	3.08	2.83	.95	.87	84.1	112.1	2.93	2.47	265.5	317.5	1.60	1.96	20.6	25.2

age level.

in³ and average total cell weight of 5.72 grams.

- 6.7 Activation characteristics of these units are presented in Table 6. For high temperature activation, times were not measureably affected by the storage conditions; at low temperature, a consistent trend to longer times regardless of the storage environment is noted. These times, however, are still substantially well within the specification.
- 6.8 It should be emphasized here that the data presented in Tables 5 and 6, and the resulting comparisons outlined above are from a relatively small sample within each test environment; therefore, strong conclusions based on the above test work should be avoided. The data does, however, show general trends. In addition, all of the above comparisons were made between units with seals that contained fine leaks. Whether the above results are indicative of the fine leak condition has not been established. More extensive testing, utilizing non-leak test samples from the same population would provide data to accomplish this. Within the scope of the test plan executed, the indication is that the fine leak rejects were not significantly affected by the environmental storage to which they were exposed.
- 6.9 Ten additional fine leak units were potted in sensor modules at Hopkins. These were subsequently forwarded to Picatinny Arsenal for high shock testing, the results of which are known to be published.
- 6.10 The remainder of the cells shown in Table 6, including the 32 acceptable cells representing excess PR-3 production, are being held as residual inventory to this contract. A possible use for these items is a more extensive test plan similar to the one discussed above and executed during this contract.

ENVIRONMENTAL TEST RESULTS02000 40 CELL FINE LEAK ACTIVATION CHARACTERISTICS

(Mode: Piston Activators, Under a 3.25 Kohm Load)

Cell Number	Time to 2.0 Volts (msec)	Time to 2.5 Volts (msec)	Time to Peak Voltage (sec)	Peak Voltage	Time at Peak Voltage** (sec)
513	<10	<10	<1	3.68	20
604	<10	<10	<1	3.65	90
551	<10	<10	<1	3.65	90
881	<10	<10	<20	3.65	90
503	83	112	<15	3.39	30
846	<10	70	<15	3.41	15
873	81	119	<15	3.43	15
562	84	95	<1	3.45	15
560	<10	<10	<15	3.54	120
852	<10	<10	<30	3.55	90
897	<10	<10	<15	3.58	15
610	<10	<10	<60	3.56	60
472	161	321	<15	3.21	15
490	167	227	<15	3.26	15
523	92	128	<15	3.31	15
554	27	116	<1	3.30	15
775	<10	<10	<30	3.54	90
608	<10	<10	<60	3.53	30
561	<10	<10	<10	3.53	100
612	<10	<10	<10	3.54	100
491	272	682	<15	3.26	15
865	320	790	<1	3.32	30
568	243	745	<15	3.30	15
755	491	795	<15	3.27	15
572	<10	<10	<1	3.56	90
855	<10	<10	<1	3.51	120
496	<10	<10	<1	3.66	30
866	<10	<10	<30	3.66	60
810	144	179	<15	3.38	15
837	120	198	<15	3.27	15
845	110	147	<1	3.50	20
485	35	147	<15	3.33	20
784	<10	<10	<1	3.65	10
597	<10	<10	<1	3.66	10
824	<10	<10	<1	3.65	45
481	<10	<10	<1	3.62	40
575	215	346	<15	3.37	30
539	361	434	<15	3.35	15
806	NOT RECORDED - EQUIPMENT FAILURE				
492	153	236	<1	3.36	20

*Total time measured from initiation of piston activator to point voltage reaches indicated voltage.

**Approximate time voltage remained at the indicated peak after first reaching that level.

7.0 PROCESS DEVELOPMENT

7.1 Tungsten Inert Gas (TIG) Welding

- 7.1.1 The G2666 cell closure has typically been made by electron beam welding of the outside diameter of the terminal plate assembly (P/N T9275568) to the inside diameter of the cell can. This process requires the time-consuming loading of the weldment assembly into a vacuum chamber. To reduce the cycle time associated with electron beam welding, tooling has been generated such that eight cells are currently loaded into a welding fixture and the cells are pumped down via a vacuum simultaneously. Processing single cells without the above fixture would be very time-consuming.
- 7.1.2 TIG welding (Tungsten Inert Gas), on the other hand, permits an open setup in the atmosphere, which results in an improvement in the cycle time required to weld each unit. This open setup with TIG welding also permits more latitude in the eventual design of high production welding equipment.
- 7.1.3 Initially, a fixture or welding nest was designed and procured to hold the G2666 cell and terminal plate assembly during the TIG welding process. After receipt and setup of this welding equipment, a total of five various configuration modifications to the G2666 terminal plate assembly were made and tested.
- 7.1.4 Figure 23 depicts modification number one, in which the wall of the existing terminal plate assembly was reduced to 0.012 inch such that it would be nearly compatible with the thickness of the cell case. The

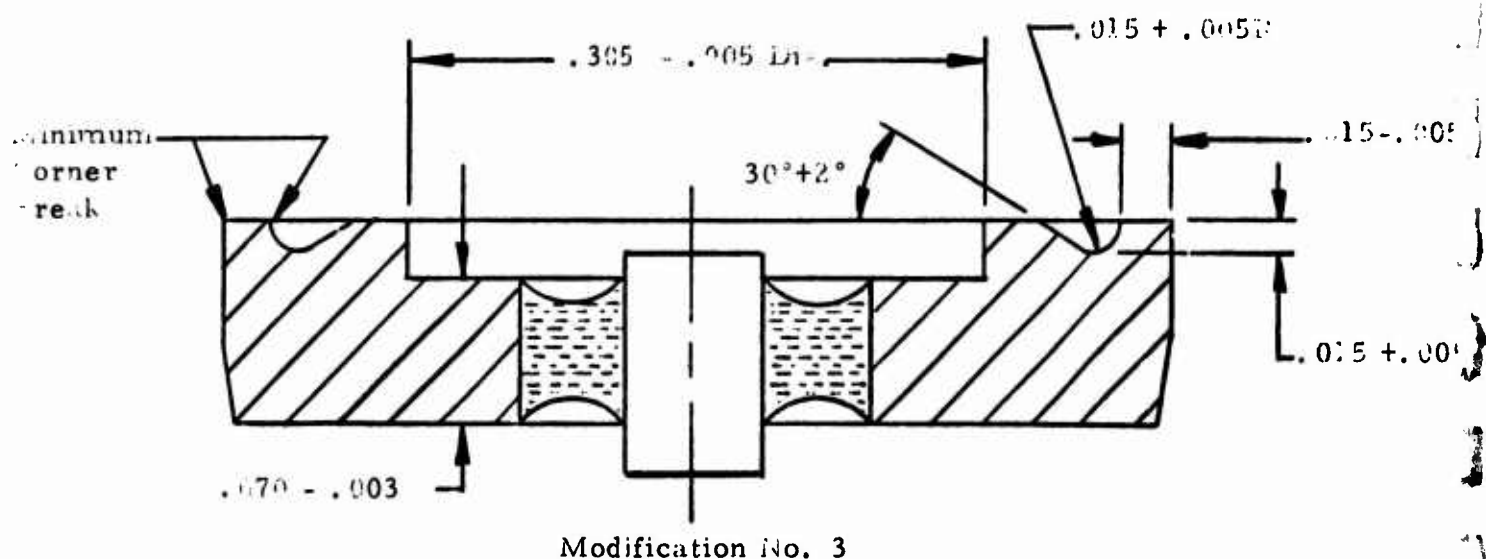
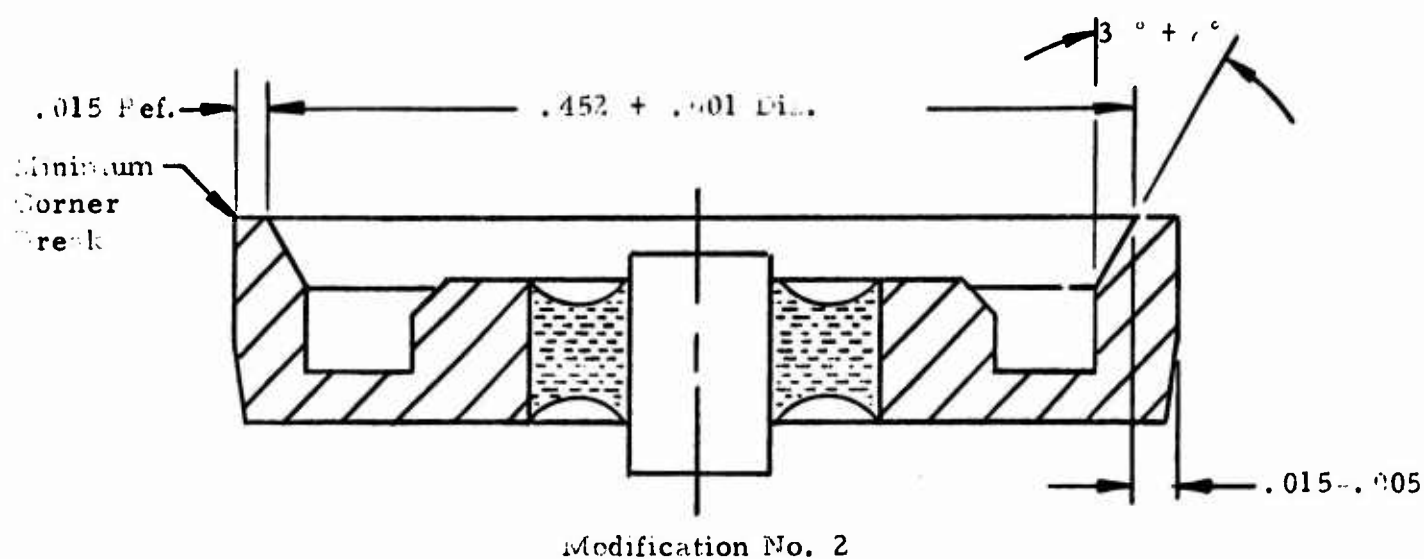
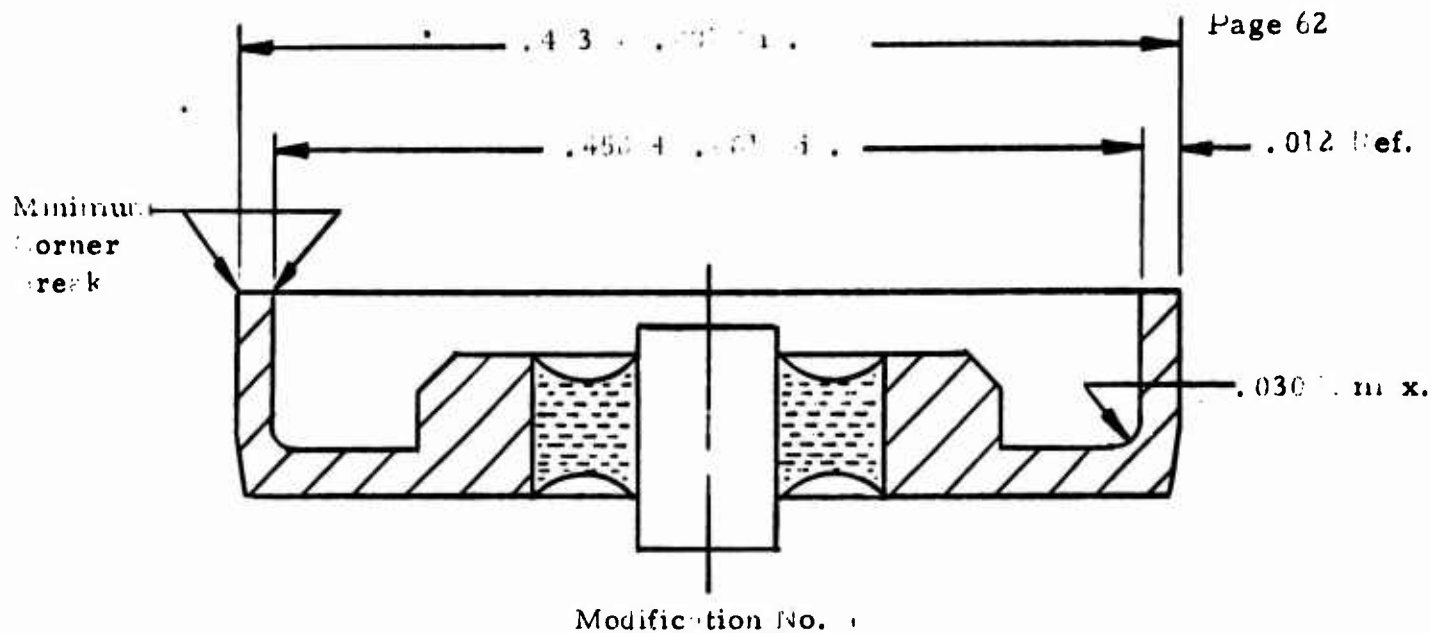


FIGURE 23

TERMINAL PLATE MODIFICATIONS FOR TIG WELDING

second configuration shown in Figure 23 is also that of the existing terminal plate assembly, with a 30° chamfer cut around the inside flange of the part. This modification resulted in a 0.015 inch flat at the top of the part, again aimed at more nearly matching the part thickness to be welded to that of the cell case. Modification number three, also presented in Figure 23 involved machining entirely new terminal plates, which again contained a 0.015 inch wall at the top edge. It was not possible to fabricate these parts from existing terminal plates, because of the increased amount of material in the basic plate as shown in Figure 23. This was added to the terminal plate configuration to serve as a heat sink which would maintain a lower temperature at the glass-to-metal seal interface during the welding process. It should be mentioned here that all three of the above modifications were similar to the existing G2666 terminal plate geometry in terms of the outside diameter, and in terms of the glass-to-metal seal configuration.

7.1.5 Initial welding parameters were established for the three header designs. During this fabrication series, it was found that the terminal reached a temperature of 200° to 300° F. Prior to TIG welding, modification numbers 1 and 2 had been leak checked both before and after machining with no leakage observed. Modification number three was welded without the glass seal and therefore could not be leak checked. Leak checking of modifications numbers 1 and 2 after these initial weld trials showed that both these configurations leaked after welding.

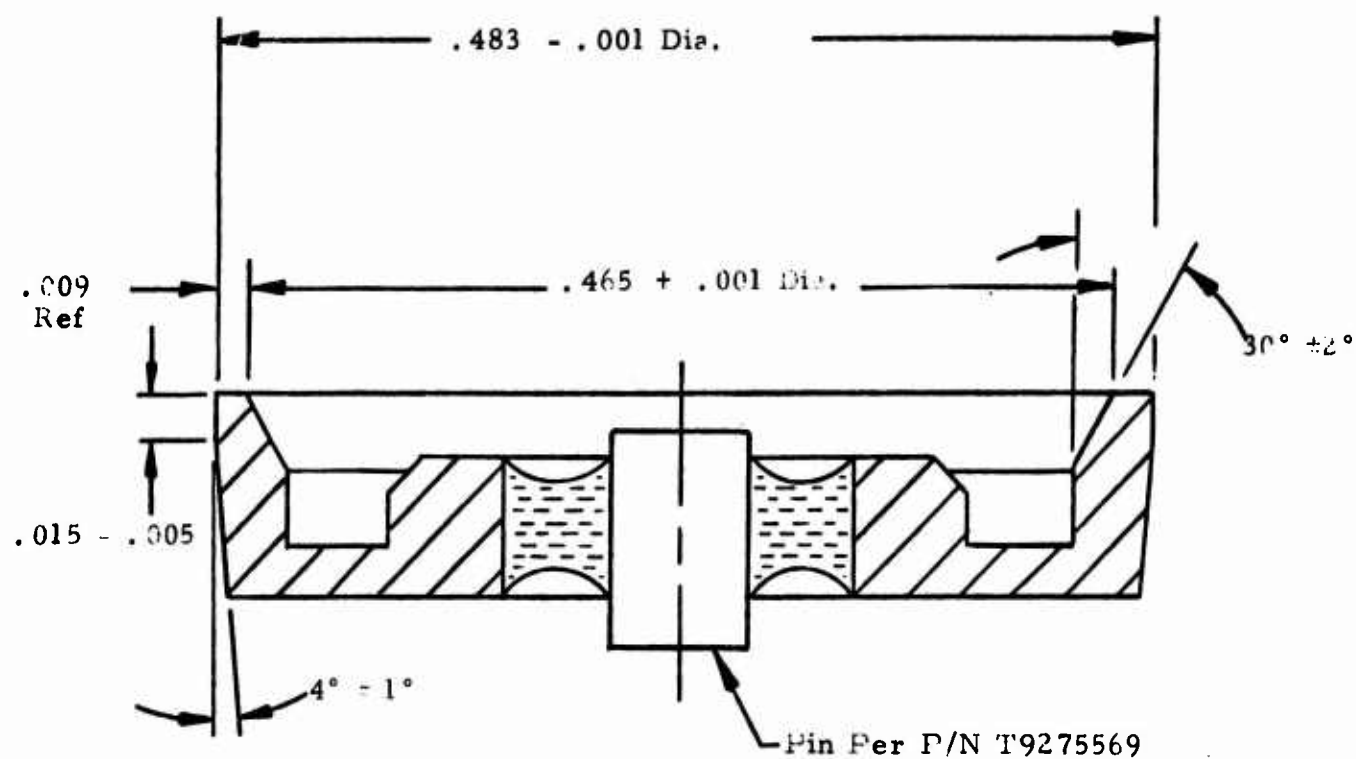
7.1.6 These initial trial tests indicated that modification numbers 2 and 3 were preferred over modification number 1, based on visual inspection of the welds after processing. Welds of all modifications were then

sectioned and etched to inspect the size and formation of the weld nugget. Good results were apparent with all three weld configurations.

7.1.7 At this point, a meeting was held between Honeywell personnel and representatives from Precision Arc Company to discuss the above results, and outline additional adjustments to the welding procedure; as well as further modifications to the terminal plate hardware design. The main recommendations resulting from this meeting were as follows:

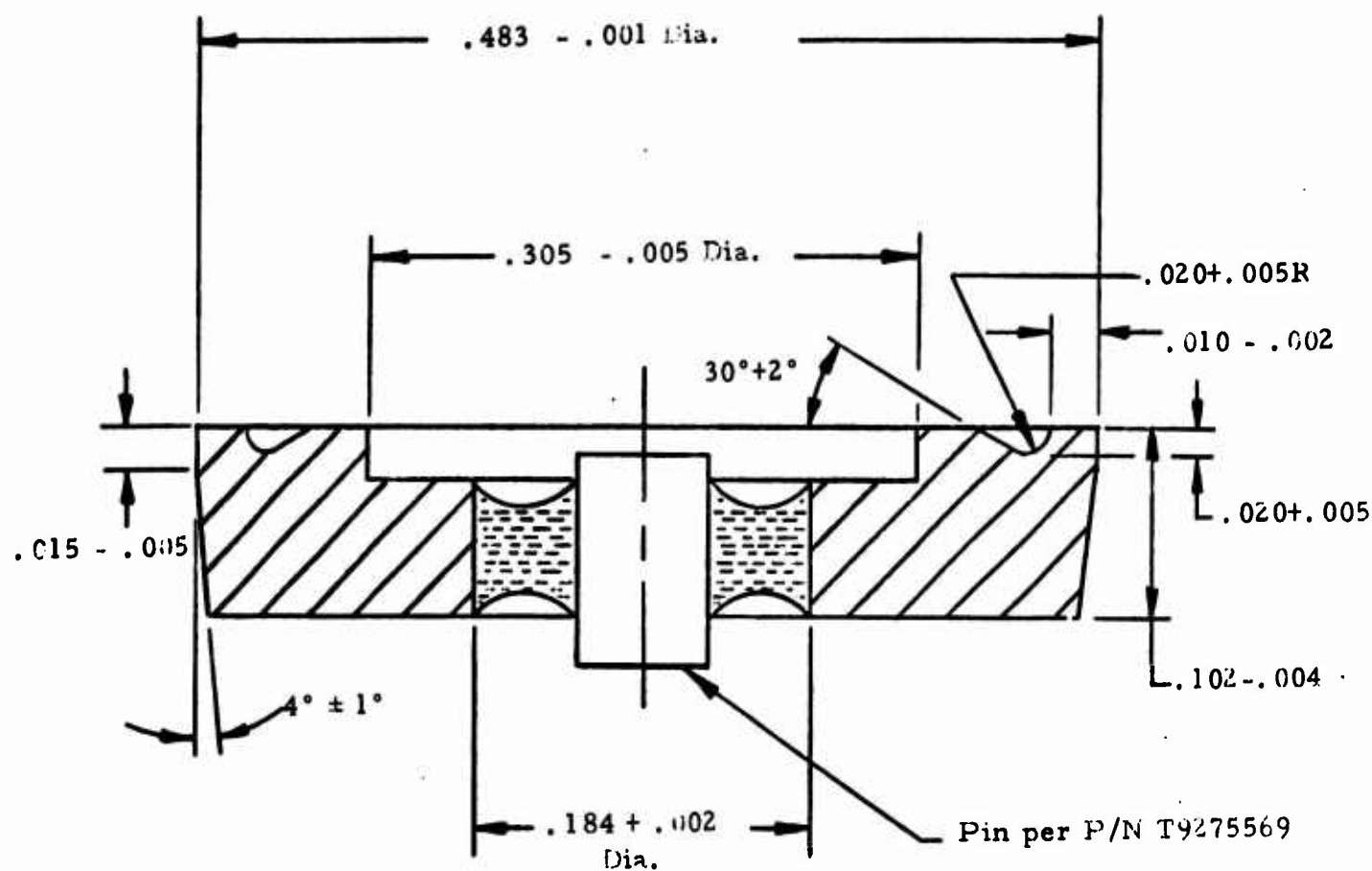
- Insure that the header or terminal plate lip thickness is approximately equal to the case wall (minimum heat will then be required to make the weld).
- The interface or fit between the header O. D. and the cell I. D. should be as tight as possible (this will prevent gapping of the cell case at the outside surface during welding).
- The header thickness should be large as possible or practical in order to provide heat sink capacity.
- The surface area of the weld joint must be thoroughly cleaned to avoid outgassing of combustible contaminants (cathode material).
- Copper shielding caps over the glass-to-metal seal area will act as additional heat sinks during welding to prevent heat accumulation.

- 7.1.8 Pertinent design detail changes were made in order to incorporate the above key technical recommendations. Terminal plate hardware modification numbers 4 and 5 depicted in Figures 24 and 25 were then fabricated. These configurations are basically the same as those shown in earlier modification numbers 2 and 3 (Figure 23) except that a larger taper has been added to the O. D. of the terminal plate. The reason for this is to provide less of a heat path into the cell case and thereby reduce the total amount of heat and time required to generate a satisfactory weld, while increasing the temperature locally where the welding action is taking place. Tests on modifications 4 and 5 have not been conducted as of this writing.
- 7.1.9 Test results of the modifications tested to date (i. e., 1 through 3) indicate that TIG welding of the G2666 terminal plate assembly to the cell case is feasible; however, these test welds were done on glass-to-metal seals prior to obtaining the corrected seals used to fabricate Lot PR-3. Heat effects, determination of the survivability of the corrected seal and optimization of the terminal plate/seal configuration still must be determined, in conjunction with the evaluation of modifications 4 and 5.
- 7.1.10 A test plan that will provide the necessary data to formulate conclusions in the above areas and recommendations for possible additional scope is given in Table 7. This plan includes an assessment of the TIG process on cell performance which should be made, since cells manufactured via this process will not be sealed in a vacuum. Execution of this plan could be a portion of the engineering development of subsequent contracts.



Modification No. 4

FIGURE 24
TERMINAL PLATE MODIFICATIONS FOR TIG WELDING



Modification No. 5

FIGURE 25
TERMINAL PLATE MODIFICATIONS FOR TIG WELDING

TABLE 7

TIG WELDING HARDWARE FABRICATION AND EVALUATION TESTING

- (1) Leak test twelve samples of each terminal plate assembly depicted by modifications 2 through 5.
- (2) TIG weld 2 samples of each modification above to standard cases, using copper shielding caps to establish TIG weld parameters. Monitor temperature with tempil sticks during welding at the terminal pin to determine heat buildup.
- (3) Bomb test all samples under Item (2) above for leaks. Further evaluate leaking units by drilling the bottom of the case to determine the location of the leak source.
- (4) Reiterate Step (2) above with 4 additional samples of each modification incorporating improvements in tooling and processing.
- (5) Repeat Step (3) for all samples welded in Step (4).
- (6) Determine the optimum terminal plate configuration, welding equipment, tooling and processes from the above work, and using this input, weld 6 units for verification of initial results.
- (7) Bomb test all samples in Step (6) above for leaks.
- (8) Fabricate, assemble and TIG weld complete cells for performance evaluation.

7.2 Cathode Tooling

- 7.2.1 Effort was expended under this contract to increase the production rate capability of G2666 cathode and reduce the labor content required to fabricate this part. This was done primarily by developing and designing equipment and tooling which would be adaptable to an existing cathode pressing slide. Drawing number DSK 72003881 presented in Appendix D contains a complete parts list of this slide mechanism, which includes items required to convert this tooling for use in the fabrication of G2666 cathodes.
- 7.2.2 The tooling that was designed and fabricated during the course of this contract are listed as Items 15, 17, 18, 19, 23, 24, 25, 26 and 27 on the above assembly drawing (P/N DSK 72003881). Prints of these items are also included in Appendix D, as well as four additional prints depicting a funnel assembly and its associated piece parts which will be used to feed cathode material into the cathode die.
- 7.2.3 The above tools have been procured and, as of this writing, are awaiting setup and installation into a Dennison Press.

APPENDIX A
TEST AND POST MORTEM DATA

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AEROSPACE AND
DEFENSE GROUP

REPORT NO 8310-81573

DEV. NO. G2666

ENGINEERING TEST REPORT

DATE 15 August 1973

PAGE 1 OF 6

ISSUED BY:

Power Sources Center

SUBJECT

Cell case depressions resulting from primer activations.

MATERIAL SUBMITTED

- 1) 34 discharged G2666 lithium reserve cells from production lot PR-1 built under contract DAAA21-73-C-0677.
- 2) 67 discharged cells of the same type used in the power source qualification test program conducted in November 1972 under contract DAAA21-72-C-0437.

BACKGROUND

The cells of group (1) were tested at Picatinny Arsenal in June 1973 in the power source configuration (dwg. #T9275619, Rev. C Power Supply Assembly). After the completion of the tests, the cells were returned to Power Sources Center for measurement. The units were upon receipt already removed from the cell holders and potting. The cells of group (2) were part of the units put through the Qualification Test Plan at GAPW during the development contract for the XM70 power source. The cells required extraction from the power supply assembly and abrasive removal of some of the potting compound before measurements could be taken.

CONCLUSIONS

- 1) The mean depression for the group (1) cells was .0350 inches with a standard deviation of .0133 inches. The range of depressions was from .0130 to .0690 inches.
- 2) The mean depression for the group (2) cells was .0166 inches with a standard deviation of .0050 inches. The range of depressions was from .0050 to .0280 inches.

KEYWORDS:

Lithium
Reserve
Activation
Case
Depression

ATTACHMENTS:

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PROCEDURE AND RESULTS

The feature being measured is the depression in the non-terminal case/surface of the cell that results from the detonation of the activating primer.

Both groups of cells were measured using a contour tracing attachment on a Jones and Lawson Model TC-14 Optical Comparator. The attachment consists of two tungsten carbide tips having end diameters of .010 inches. One tip is placed on the piece to be measured, the other is viewed on the screen of the comparator. After a proper screen scale reference is established, the bottom contour of the cell case is traced with one of the tips to find the point of maximum depression. The measurement is obtained by determining the amount of base table movement necessary to return the reference tip to the zero position. Accuracy of the reading is rated at .0001 inches.

The resulting data were then processed by computer using a BASIC LSTAT/ program, the output of which is given in Figures 1 and 2. The individual cell readings are given in Table I.

TABLE I
CASE DEPRESSIONS - G2666

Group (1)

<u>Cell #</u>	<u>Depression</u>	<u>Cell #</u>	<u>Depression</u>
426	.0213	312	.0270
209	.0225	325	.0310
432	.0233	336	.0225
243	.0272	393	.0250
388	.033	382	.0275
55	.0410	390	.0370
10	.0293	223	.0130
89	.0230	384	.0465
174	.0417	287	.0450
188	.0262	185	.0405
145	.0456	277	.0210
317	.0506	157	.0575
311	.0240	326	.0250
13	.0440	234	.0570
240	.0495	15	.0690
98	.0190	378	.0290
316	.0448	119	.0510

Group (2)

624	.017	632	.015
737	.024	772	.020
733	.014	584	.020
754	.0225	369	.010
785	.0155	773	.024
740	.017	411	.005
757	.017	758	.017
541	.026	674	.013
761	.024	636	.016
610	.027	360	.013
146	.022	650	.017
627	.018	497	.019
633	.007	628	.019
741	.015	714	.013
790	.016	700	.014

TABLE I (Cont'd)

Group (2)

<u>Cell #</u>	<u>Depression</u>	<u>Cell #</u>	<u>Depression</u>
767	.0115	682	.015
766	.028	494	.013
787	.014	591	.015
660	.019	413	.023
753	.012	707	.012
723	.021	598	.018
725	.006	669	.022
378	.010	430	.006
756	.018	366	.023
784	.013	786	.028
601	.015	782	.014
496	.0175	593	.011
678	.013	777	.016
684	.014	727	.016
611	.017	769	.018
742	.0185	692	.015
575	.012	743	.013
685	.018	607	.014
490	.018		

DEFINE FILE
1-1-1

FIGURE 1
Cell Group (1)
CAGE Tension

ENTER OPERATION CODE: (TO GET CODE LIST ENTER 0015)

34 SAMPLES, SMALLEST = .0130, LARGEST = .0900
RANGE = .0760, MEDIAN = .0301

MEAN = .03512, STANDARD DEVIATION = .013346

VARIANCE = .00178135-03

3-SIGMA TOLERANCE: +- .0400, -.0050 to .0751

ENTER LOWER AND UPPER SPECIFICATION LIMITS: .0120, .0700

SPECIFICATION LIMITS: LOWER = -1.72, UPPER = 2.32 SIGMA

CONTROL CHART: L1, L2, SAMPLE SIZE 5

UCL(1) = .07, LCL(1) = .01

UCL(2) = .07, LCL(2) = .01

*

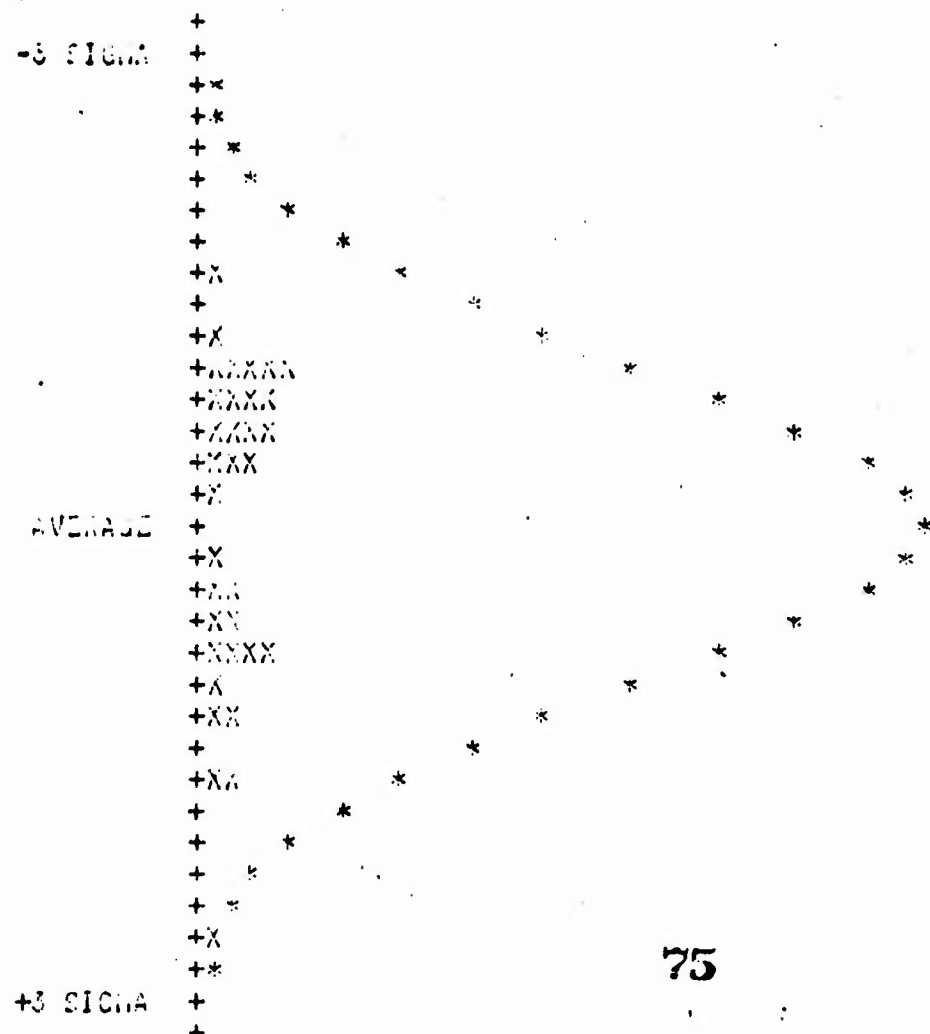


FIGURE 2
CELL GROWTH (2)
CASE: DEPRESSION

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prevent further reproduction

Photos of various portions of the dissection were taken. A set is in central file for reference and a set was given to the P/A CPO.

POST MORTEM REPORT

Cell # 205 Lot # PR1

G2666 Li Reserve Sleeve

Temp at Discharge room am: F

Date 7/17/73

Failure Comments: Dead short at activation in power source

a) extracted from pwr source .4 ohm short; b) extreme dent in case bottom-approx. .050 to .060 (see attach.); c) cell height .827 to .829 OD = .494 at top and .502 at bot.

OUTER

(1) Cell Voltage Prior to Opening OCV 0 CCV 0 KLoad N/A

(2) Leakage None Where ----- Damage abnormal activation de-

(3) Resistance .5 ohm prior to turning down cell on lathe. pression.

INNER

(4) Resistance .5 ohm after turning down cell on lathe

(1) Ampul: Describe Breakage completely shattered

% Free of Glass 50%

(2) Ampul Supports: Qty. N/A Thickness N/A

(3) Ohm Resistance between anode & case N/A See
Ohm resistance between cathode & case N/A Conclusions

(4) Anode: Completely consumed

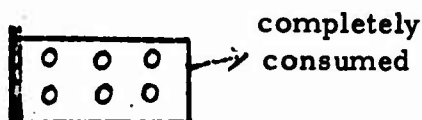
Corrosion & Pattern

Condition of connectors: ----- Screen: -----

Color/residue: Ampul Side:



Separator Side:

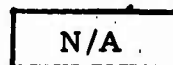


(5) Separator: NA

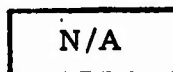
Seal with insulator N/A

Ohm Resistance N/A

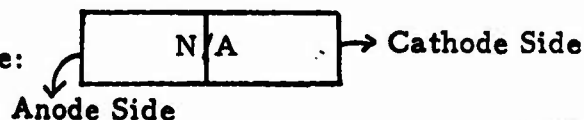
Color/Residue: Anode Side:



Cathode Side:

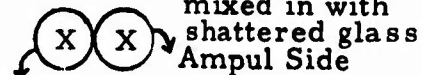


Inner Face:



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Bottom Inner Face: N/A





POST MORTEM REPORT (Contd)

(6) Cathode: Hardness brittle Color black

(7) Case: Vertical:

N/A

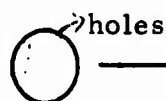
Bottom:  A tan to brown discoloration in one small area. Grey white stained throughout.

Term Plate: N/A Ohm resistance 

(8) Electrolyte Liquid No Gas none detectable when opened

(9) Insulators: Term Plate

Bottom



See below (8, 9, 10)

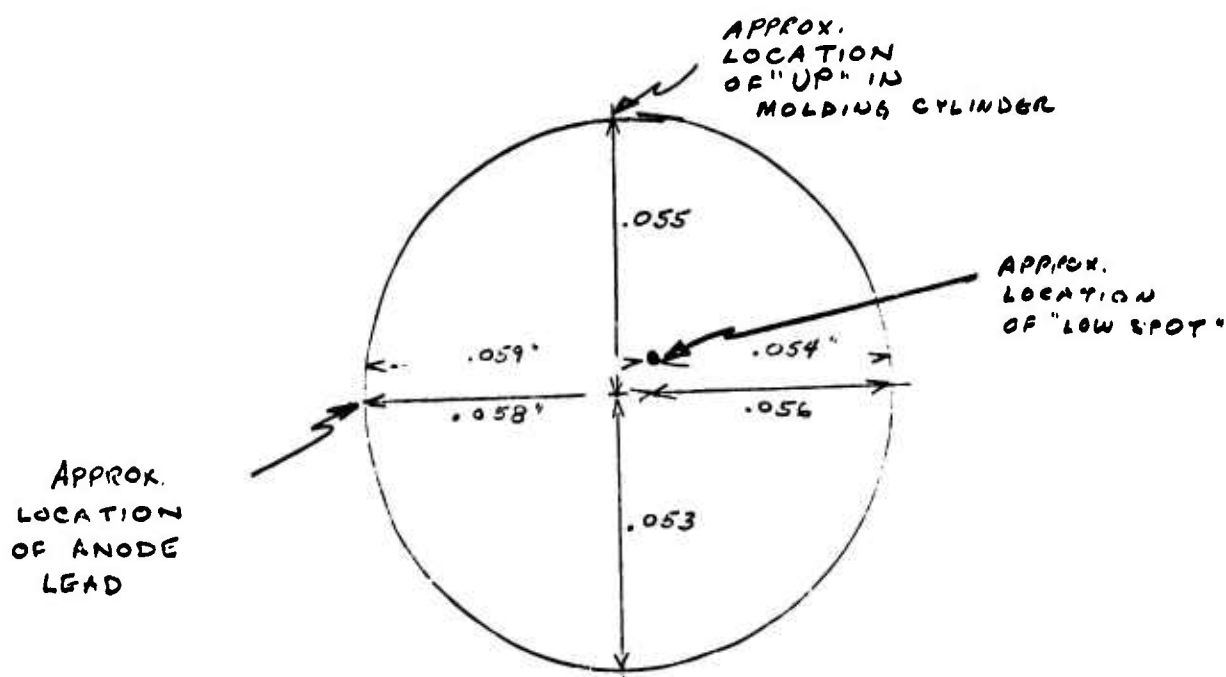
SUMMARY

- 1) The internal resistance of the cell was continually monitored during dissection - approx. .2 to .3 ohm.
- 2) The bottom of the cell was cut first, and at approx. 90% around the case OD. The jewlers saw penetrated the cathode and separator. A pull on the saw caused by a snag on an internal component was felt.
- 3) The cell resistance at this point fluctuated between .5 ohm to ∞ depending on whether the bottom portion was compressed or uncompressed.
- 4) The bottom portion of the cell was removed; however, the internal resistance was noted to be at a 400 to 500 ohm level.
- 5) When just the area of the saw pull was pressed inwardly, the 400 to 500 ohm reading returned to the very high reading obtained before the cell bottom was removed (see #3).

- 6) Other areas were pressed and no shorting was detectable.
- 7) The area of the saw pull was pressed toward the cathode and the 400 to 500 ohm short reappeared. Apparently, this short was caused by the sawing operation and not related to the .5 ohm short reading at the start of the dissection.
- 8) In examining the internal bottom portion of the cell, a rectangular depression was noted through the separator to the insulator.
- 9) A blunt instrument was used in clearing away the separator and a depression was detected on the insulator.
- 10) The bottom insulator was removed and holes were visible through it.
- 11) The dissection was stopped at this point with cause of shorting determined.

CONCLUSION

- 1) The internal short was due to a metal to metal contact between the extended portion of the anode lead and the bottom of the case. Abnormal case depression contributed to the occurrence of the short by pressing the case against the insulator, separator and anode lead (metal-to-metal .5 ohm short). The case stain, insulator holes, and rectangular depression are all in direct line with the anode lead.
- 2) The 400 to 500 ohm short in the case was due to the saw tooth making contact with anode screen and pulling metal against the cathode. A case to cathode resistance reading will normally exhibit a 400 to 700 ohm resistance reading.



		<u>DEPTH OF DEPRESSION</u>
ALONG HORIZONTAL &	LEFT TO RIGHT	.058 & .056
" VERTICAL &	TOP TO BOTTOM	.055 & .053
HORIZONTAL FROM LOW SPOT LEFT TO RIGHT		.059 & .054



**AEROSPACE AND
DEFENSE GROUP**

REPORT NO 8310-92673

DEV. NO. G2666

ENGINEERING TEST REPORT

DATE 27 September 1973

PAGE 1 OF 5

ISSUED BY:

Power Sources Center

SUBJECT

Discharge testing of G2666 lithium reserve cells containing a modified anode screen assembly.

MATERIAL SUBMITTED

A quantity of six (6) G2666-25 cells fabricated at Power Sources Center in August 1973 under Contract DAAA21-73-C-0677.

OBJECTIVE

Determine if the change in anode screen configuration will affect the discharge characteristics of the cell.

BACKGROUND

In the acceptance testing of the first lot (PR-1) of cells for Contract -0677, a failure was experienced on one power source assembly, the cause of which was assigned to an anode lead/outer case short circuit. The anode lead was welded to the collector screen such that .030/.050" of it extended past the screen. At activation, when the cell case bottom deformed, the extended portion of the lead pierced the internal plastic insulation in this area and contacted the outer case causing a short circuit condition. When the contact was made, voltage on the power source fell immediately below the minimum acceptable level.

The corrective measure resulting from the failure analysis was to weld the lead in a position away from the bottom of the screen, thus preventing the condition described above. Figure 1 shows the old and modified anode lead configurations.

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		R. J. Horning	
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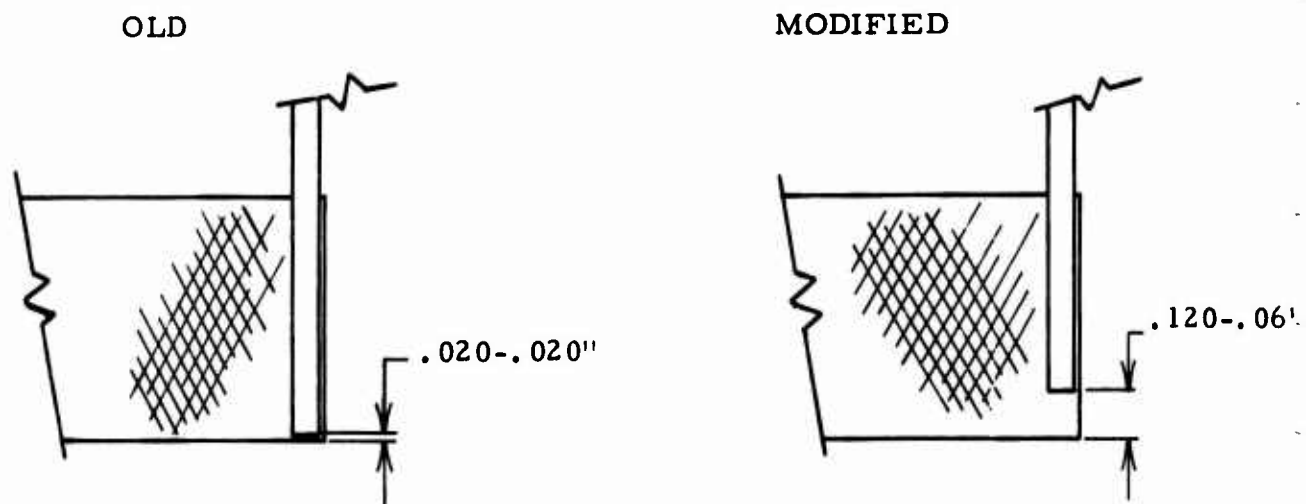
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KEYWORDS:

G2666
Lithium
Reserve
Anode Lead

ATTACHMENTS:

FIGURE 1
Anode Lead Change



On the request of the customer, lot R-25 was fabricated with the anode lead modified as shown. All other characteristics of the cells were per baseline documentation.

CONCLUSIONS

1. All cells discharged in excess of the minimum life requirement of 60 hours to 2.5 volts.
2. Five of six cells provided output comparable to baseline units.
3. The sixth cells, #1447, had output significantly lower than the other units in the group. Post test dissection and analysis did not establish an assignable internal cause for the difference. There was no indication from the analysis that the anode lead change caused the change in output for cell 1447.
4. On the basis of the data, it is concluded that the change in the anode lead position did not affect typical cell output.

PROCEDURE AND RESULTS

All cells were activated with electrically fired piston activators after being conditioned in a +135°F environmental chamber for one hour. The cells were then discharged through 3.25K ohms until the voltage level decayed below 2.0 volts.

Environment during discharge was also +135°F. Activation profiles were monitored with a Honeywell 1508-A Visicorder and voltage during discharge was recorded with a Honeywell Class 16 Multipoint recorder. The frequency of voltage reading on the latter is every 2-1/2 minutes.

A summary of activation results is given in Table I and tabulated output data are in Table II.

As indicated in the data, active life to 2.5 volts was typically in excess of 100 hours which is in the range of normal output for the G2666 cell. One cell, #1447 had an active life distinctly lower than the others at 66 hours. A post test dissection of the cell was made to identify any internal defects that could have caused the difference in life. None were found - connections were intact, there was no indication of shorting either through the separator or bottom insulation and there was no sign of corrosion on any metal parts. The only abnormal condition was the small almost non-existent amount of lithium left on the anode screen. An estimated 95% of the material was consumed. Normal cell discharge, and especially the active life for this unit (120 hours to 2.0 volts), is not sufficient to deplete the anode to such a low level. Anode capacity is nominally about 300 mAHrs. Past experience has shown that premature total or near total anode depletion results from a short circuit condition either sustained or intermittent. In the absence of identifiable internal short circuiting (also, unit still had voltage at time of dissection), one could speculate about the occurrence of an accidental external short; however, this could not be confirmed.

A copy of the post mortem report for cell #1447 is attached for reference.

TABLE I
ACTIVATION CHARACTERISTICS - G2666

Lot R-25 - +135°F

Mode: a) Piston activators
 b) Under a 3.25K ohm load

Unit #	Time To 2.0 Volts (m sec)	Time To 2.5 Volts (m sec)	Time To Peak Voltage (sec)	Peak Voltage	Time At Peak Voltage** (sec)
1443					
1444	25	28	15	3.65	15
1445	<10	<10	<1	3.71	30
1446	<10	<10	30	3.69	10
1447	<10	<10	15	3.73	20
1448	<10	<10	15	3.64	20

NOT RECORDED - EQUIPMENT DIFFICULTY

*Total time measured from initiation of piston activator to point voltage reaches indicated voltage.

**Approximate time the voltage remained at the indicated peak after first reaching that level.

TABLE II

DISCHARGE DATA - G2666

Lot R-25 - 3.25K Ohms - +135°F

Cell #	Active Life (hrs)		Avg. Voltage ¹		Avg. Current (mA)		Capacity (mAhrs)		Avg. Power (mW)		Energy (mWhrs)		Whrs/in ³		Whrs/lb	
	to 2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V	2.5V	2.0V
1443	104	270	3.30	2.69	1.02	.83	106	224	3.37	2.23	350	602	2.16	3.72	27.8	47.7
1444	104	262	3.30	2.74	1.02	.84	106	220	3.37	2.30	350	603	2.16	3.72	27.8	47.8
1445	103	258	3.29	2.69	1.01	.83	104	214	3.32	2.23	342	575	2.11	3.55	27.1	45.6
1446	102	271	3.29	2.69	1.01	.83	103	225	3.32	2.23	339	604	2.09	3.73	26.9	47.9
1447	66	120	3.29	2.86	1.01	.88	66.7	106	3.32	2.52	219	302	1.35	1.86	17.4	23.9
1448	103	270	3.30	2.68	1.02	.82	105	221	3.37	2.20	347	594	2.14	3.67	27.5	47.1
Avg.																
w/1447	97.0	242	3.30	2.73	1.02	.84	98.5	202	3.35	2.29	325	547	2.00	3.38	25.8	43.3
w/o 1447	103.2	266	3.30	2.70	1.02	.83	105	221	3.35	2.24	346	596	2.13	3.68	27.4	47.22

¹Integrated value for entire active life up to the indicated voltage level.

Energy density values on basis of total cell volume of .162 in³ and average total cell weight of 5.72 grams.

POST MORTEM REPORT

Cell # 1447 Lot # 25

8201 Li Reserve Sleeve

Temp at Discharge +135 °F

Date 15 August 1973






Failure Comments: None (66 hours to 2.5v Balance of lot had 100 hours average to 2.5v)

OUTER

2/13/73


- (1) Cell Voltage Prior to Opening OCV 2.18v 3.25K CCV 2.02v 10 K KLoad 2.17v
- (2) Leakage None Where ----- Damage None
- (3) Broken glass detectable when battery is shaken, no voltage fluctuation
1.96v on 8/15/73


INNER

- (1) Ampul: Describe Breakage moderate to heavy sides shattered
% Free of Glass 30
- (2) Ampul Supports: Qty. 1 Thickness .154
- (3) Ohm Resistance between anode & case sporadic (cell still has voltage)
Ohm resistance between cathode & case 1 to 2 K
- (4) Anode: 95% consumed (appeared heavier than normal under similiar conditions on other cells.)
Corrosion & Pattern: Reddish brown
Condition of connectors: OK Screen: OK (hard not pliable)
Color/residue: Ampul Side:
Screen 95% visible
Separator Side:
Screen 90% visible
- (5) Separator:
Seal with insulator OK
Ohm Resistance ∞ between and through layers
Color/Residue: Anode Side:  Reddish Brown
Dark Brown  somewhat more brittle
Cathode Side:  Soft Blueish Black in color
Soft and White
Inner Face:  Anode Side Cathode Side
some minor black staining
Bottom Inner Face: N/A  Ampul Side
90% gone, mixed in with glass Insulator Side N/A

POST MORTEM REPORT (Contd)


(6) Cathode: Hardness Brittle Color Black

(7) Case: Vertical: Shiny
 some black surface stain


Bottom: 

Term Plate: ∞ Ohm resistance  some black KM
outer pin to inner lead = 0Ω

(8) Electrolyte Liquid Yes Gas Yes when opened

(9) Insulators: Term Plate OK some black KM


Bottom OK

 grayish white at activation

Conclusion:

No evidence detectable for difference in life to 2.5v
(a) In referring to voltage

Power Supply #7 at 4.74V

POST MORTEM REPORT

Cell # R 647 Lot # PR-2

210 Ω

G2666 Li Reserve Sleeve

Temp at Discharge ambient °F

100 μ f

Date 8/27/73

Failure Comments: Sporadic voltage during discharge

OUTER

Cells firmly implanted in power source

10K load 3.25

(1) Cell Voltage Prior to Opening OCV 2.34 CCV 2.27 KLoad 2.19

(2) Leakage None Where ---- Damage None

INNER

(1) Ampul: Describe Breakage Heavy - completely shattered

% Free of Glass 95%

(2) Ampul Supports: Qty. 1 Thickness .156

(3) Ohm Resistance between anode & case ∞

Ohm resistance between cathode & case 2K + varying

(4) Anode: 90% consumed

Corrosion & Pattern

Tear metal when pulled

Condition of connectors: good Screen: good

Color/residue: Ampul Side:

Gray



Separator Side:

Reddish brown



(5) Separator:

Seal with insulator OK In tact

Ohm Resistance ∞ straight through

Color/Residue: Anode Side:



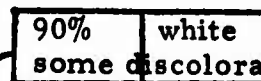
Reddish gold throughout
Some dark spec
Somewhat brittle

Cathode Side:



Blue black throughout
Generally soft

Inner Face:



Anode Side

Soft

Cathode Side

Bottom Inner Face: 90% gone

mixed in
with glass Insulator Side



N/A

Ampul Side

Preceding page blank

POST MORTEM REPORT (Contd)

(6) Cathode: Hardness Brittle Color Black


(7) Case: Vertical:  Moderately shiny to bright
Some black surface stain

Bottom:  Shiny

Case depression .017


Term Plate: ∞ ^{pin to} _{side} Ohm resistance

Term Plate .5 Ω straight through

 Some KM rubber cement


Shiny

(8) Electrolyte Liquid No Gas Yes when opened

(9) Insulators: Term Plate  KM

Cork colored

Bottom

 Black with irregularly shaped gray white stain

Summary

Conclusions

1. Aside from a somewhat heavier than usual anode consumption, the cells were similar in all respects to normally discharged ambient room cells.
2. No internal shorts were detectable.
3. No discrepancies in construction were found; and no evidence of assembly defects which would lead to voltage fluctuation
4. As a power source, both cells were identical in appearance.

Power Supply #7 at 4.74V

POST MORTEM REPORT

Cell # R-732 Lot # PR-2

G2666 Li Reserve Sleeve

Temp at Discharge ambient °F

Date 8/27/73

Failure Comments: Sporadic voltage during discharge

AC Internal Impedance = 60 μ f

AC Internal Resistance = 240 Ω

OUTER

Cells firmly implanted in pwr source 10K load 3.25

(1) Cell Voltage Prior to Opening OCV 2.33 CCV 2.30 KLoad 2.21

(2) Leakage None Where ----- Damage None

INNER

(1) Ampul: Describe Breakage Moderately heavy-top in tact- sides shattered

% Free of Glass 90%

(2) Ampul Supports: Qty. 1 Thickness .154

(3) Ohm Resistance between anode & case ∞

Ohm resistance between cathode & case 1K

(4) Anode: 98% consumed

Corrosion & Pattern

tear metal when pulled

Condition of connectors: good Screen: good

Color/residue: Ampul Side:



Screen completely visible
reddish gold tint

Separator Side:



Same as above

(5) Separator:

Seal with insulator OK In tact

Ohm Resistance ∞ straight through

Color/Residue: Anode Side:



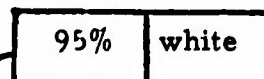
Reddish gold throughout
Moderately brittle

Cathode Side:



Blue black throughout
Soft

Inner Face:



Soft

Cathode Side

Anode Side

Bottom Inner Face: 90% gone
mixed in



N/A

Ampul Side

with glass Insulator Side

POST MORTEM REPORT (Cont'd)

(6) Cathode: Hardness Brittle Color Black

(7) Case: Vertical:



some black surface stain

Bottom:



Shiny

Bottom Case Depression .027

Term Plate: ∞ pin to case

Ohm resistance



95% coated with KM

Term Plate .9 Ω straight throughout

(8) Electrolyte Liquid No Gas Yes when opened

(9) Insulators: Term Plate some KM



Cork colored

Bottom



Grayish white - central stain

Summary

Conclusions

1. Aside from a somewhat heavier than usual anode consumption, the cells were similar in all respects to normally discharged ambient room cells.
2. No internal shorts were detectable.
3. No discrepancies in construction were found; and no evidence of assembly defects which would lead to voltage fluctuation.
4. As a power source, both cells were identical in appearance.

Power Supply #1: at 2.44V

POST MORTEM REPORT

Cell # R-462 Lot # PR-2

G2666 Li Reserve Sleeve

Temp at Discharge +135 °F

Date 8/27/73

Failure Comments: Shorter life to 2.5V than observed in balance of lot

AC Internal Impedance 700 μ f

AC Internal Resistance 24 Ω

OUTER Cell firmly implated in power source

(1) Cell Voltage Prior to Opening OCV 0 CCV 0 KLoad 0

(2) Leakage None Where — Damage None

INNER

(1) Ampul: Describe Breakage Heavy 100% shattered

% Free of Glass 100

(2) Ampul Supports: Qty. 1 Thickness .160

(3) Ohm Resistance between anode & case ∞

Ohm resistance between cathode & case 5K Sporadic

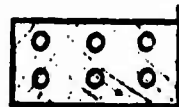
(4) Anode: 100% consumed

Corrosion & Pattern

tear metal on pull

Condition of connectors: OK Screen: Good

Color/residue: Ampul Side:



Separator Side:



Screen Dark reddish brown in color

(5) Separator:

Seal with insulator OK

Ohm Resistance ∞ straight through and ∞ in dark areas

Color/Residue: Anode Side:

mod,
brittle

Dark reddish brown through out with Black areas

Cathode Side:



Blue black throughout Soft

Inner Face:

white cream color
some dark areas

Cathode Side

Anode Side

N/A

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Bottom Inner Face: 70% gone

mixed in

with glass Insulator Side

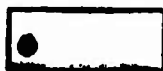


Ampul Side

POST MORTEM REPORT (Contd.)

(6) Cathode: Hardness Brittle Color Black

(7) Case: Vertical:



Dull to shiny with some areas of black

Bottom:



irregularly shaped black surface stain

Case Depression .037 pin to

Term Plate: ∞ side Ohm resistance

Term Plate .6 Ω straight through



Heavy black stain and KM

(8) Electrolyte Liquid No Gas Yes when opened

(9) Insulators: Term Plate



some KM cork colored

Bottom



irregularly shaped black to grey white coating

Conclusions

1. Aside from a somewhat heavier than usual anode consumption, the cells were similar in all respects to normally discharged high temp. cells.
2. No internal shorting was found
3. No assembly or construction defects were found which could have lead to shorter life of either cell.
4. As a power source, both cells were identical in appearance.

Power Supply # 14 at 2.44V

POST MORTEM REPORT

Cell # R-702 Lot # PR-2

G2666 Li Reserve Sleeve

Temp at Discharge +135 °F

Date 8/27/73

Failure Comments: Shorter life to 2.5V than observed in balance of lot

AC Internal Impedance 530 μ f

AC Internal Resistance 12 Ω

OUTER Cells firmly implated in power source

10K load 3.25

(1) Cell Voltage Prior to Opening OCV 2.39 CCV 2.38 KLoad 2.37

(2) Leakage None Where ---- Damage None

INNER

(1) Ampul: Describe Breakage Heavy 100% shattered

% Free of Glass 95%

(2) Ampul Supports: Qty. 1 Thickness .153

(3) Ohm Resistance between anode & case ∞

Ohm resistance between cathode & case 800 to 1900 Ω

(4) Anode: 90% consumed

Corrosion & Pattern

Tear metal on pull

Condition of connectors: OK Screen: OK

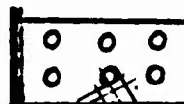
Color/residue: Ampul Side:



Reddish Gray throughout

Screen lightly visible

Separator Side:



Dark reddish brown throughout

(5) Separator:

Seal with insulator OK

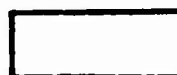
Ohm Resistance ∞ straight throughout

Color/Residue: Anode Side:



Reddish brown throughout

Cathode Side:



Blue black throughout
Moderately soft

Inner Face:



Anode Side

Cathode Side
Some discoloration

Bottom Inner Face: 80% gone



N/A
Ampul Side

Insulator Side

POST MORTEM REPORT (Contd)

(6) Cathode: Hardness Brittle Color Black

(7) Case: Vertical:  Irregular column shaped black surface stains

Case depression .024

Bottom: 

Term Plate: ∞ ^{pin to} ~~case~~ Ohm resistance  Heavy black stain & KM

Term Plate: 3 Ω straight through

(8) Electrolyte Liquid No Gas Yes when opened

(9) Insulators: Term Plate



Some KM cork colored

Bottom



Grayish white coating

Conclusions

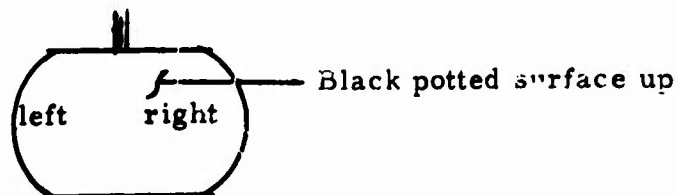
1. Aside from a somewhat heavier than usual anode consumption, the cells were similar in all respects to normally discharged high temp. cells.
2. No internal shorting was found.
3. No assembly or construction defects were found which could have lead to shorter life of either cell.
4. As a power source, both cells were identical in appearance.

BOTTOM CASE DEPRESSIONS FROM ACTIVATION

LOT PR-2

<u>Power Source #</u>	<u>Cell # (Left)*</u>	<u>Depression</u>	<u>Cell # (Right)*</u>	<u>Depression</u>
1	465	.031"	457	.026"
2	688	.023	698	.032
3	733	.023	678	.019
4	559	.029	470	.026
5	665	.030	461	.032
6	746	.029	451	.034
7	647	.017	732	.027
8	644	.051	896	.025
9	453	.029	474	.034
10	666	.024	458	.022
11	712	.027	578	.030
12	662	.014	581	.031
13	613	+.014**	660	.024
14	462	.037	702	.024
15	694	.040	477	.040
16	682	.034	627	.022
17	754	.031	635	.032
18	676	.036	741	.043
<u>Average</u>		<u>.0297</u>		<u>.0291</u>
<u>Total Average</u>		<u>.0294</u>		

*

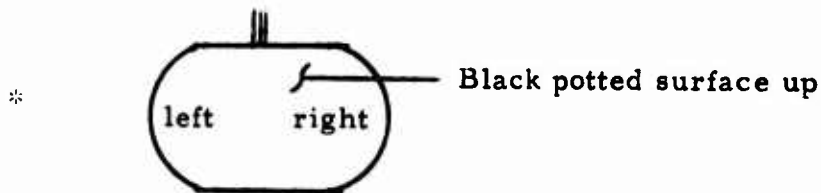


**Case bottom expanded the amount shown - This occurs on some units after considerable time has elapsed after discharge. Value not included in averages.

BOTTOM CASE DEPRESSIONS FROM ACTIVATION

LOT PR-3

<u>Power Source #</u>	<u>Cell # (Left)*</u>	<u>Depression</u>	<u>Cell # (Right)*</u>	<u>Depression</u>
A	1370	.034	1388	.036
B	1405	.024	1365	.028
C	1361	.027	1380	.033
1 +135°F	988	.019	1076	.021
2 "	961	.021	1100	.032
3 "	1473	.024	1342	.017
4 "	1073	.036	1369	.031
5 "	914	.018	944	.020
6 "	1207	.034	1204	.022
7 "	1538	.025	1510	.021
8 "	1171	.032	1145	.019
9 "	1421	.026	992	.021
10 -35°F	1233	.020	1139	.036
11 "	1479	.017	1166	.023
12 "	1293	.020	965	.018
13 "	1167	.021	1123	.042
14 "	1215	.022	1254	.025
15 "	1142	.016	1350	.019
16 "	1362	.027	1414	.024
17 "	1250	.022	1257	.019
18 "	1274	.025	925	.017
19 Room	1067	.021	1158	.022
20 "	1056	.031	1106	.034
21 "	1186	.027	1230	.031
22 "	1319	.022	1016	.026
23 "	1377	.022	1407	.016
24 "	1135	.027	1503	.023
25 "	1051	.022	1294	.021
26 "	1264	.020	1580	.025
27 "	1332	.020	1023	.018
<u>Average</u>		<u>.0241</u>		<u>.0247</u>
<u>Total Average</u>		<u>.0244</u>		



Units were also checked for primer color coding. The primer surface facing the open (potted) side of the molding surface was green for every item. The upper surface, on which the firing pin strikes, could not be checked due to damage incurred at detonation.

PROCESS OUTLINE

Spec. #PS-106-A
Northeast Electronics - Glass Seal

PART PREPARATION

A. 52 Alloy pin

1. Ferrodex - 10 min.
2. Water - water
3. HCl inhibited 10 min.
4. Water - water
5. Fe_2Cl_3 etch - Time by visual inspection for matte finish
6. Water - water
7. Acetone rinse dry
8. Anneal

B. S/S Body

1. Ferrodex 10 min.
2. Water - water
3. HCl inhibited
4. Water - water
5. Acetone - dry
6. Vacuum anneal 1900° 1/2 hr
7. Etch HCl & H_2O_2 - Visual for heavy etch in O. D. of body

C. Glass preform - N. E. GC17-101-6

1. Acetone wash - dry

PROCESS OUTLINE

Seal-A-Metic Manufacture

9010 Glass

PARTS PREPARATION

A. Glass Bead

1. Methanol clean
2. Oven dry

B. 52 Alloy Pin

1. Vapor degrease
2. Light etch (50% HCl solution at 150°F) until Matte Gray finish obtained. Do not remove more than .0003" from diameter.
3. Water rinse (dirty)
4. Water rinse (clean)
5. Methanol rinse (dirty)
6. Methanol rinse (clean)
7. Oven dry (15 minutes at 300°F)
8. Anneal 1900°F for 20 minutes in hydrogen

C. Plate (SS)

1. Vapor degrease
2. HCl (50% solution) at 150°F for 2 minutes
3. Water rinse (dirty)
4. Water rinse (clean)
5. Methanol rinse (dirty)
6. Methanol rinse (clean)
7. Oven dry (15 minutes at 300°F)
8. Anneal 1800°F for 10 minutes in hydrogen

FIXTURE & SEAL

A. Fixture as per sketch

B. Seal

1. 1800°F in exothermic 6% CO₂ atmosphere
Belt speed 5" per minute - approx. 20-25 minutes
 2. Cooling zone
Out temp at 180°F - approx. 40-50 minutes
 3. Cool at ambient in carbon fixture 1 to 1-1/2 hrs.
- 1 to 1-1/4 hrs

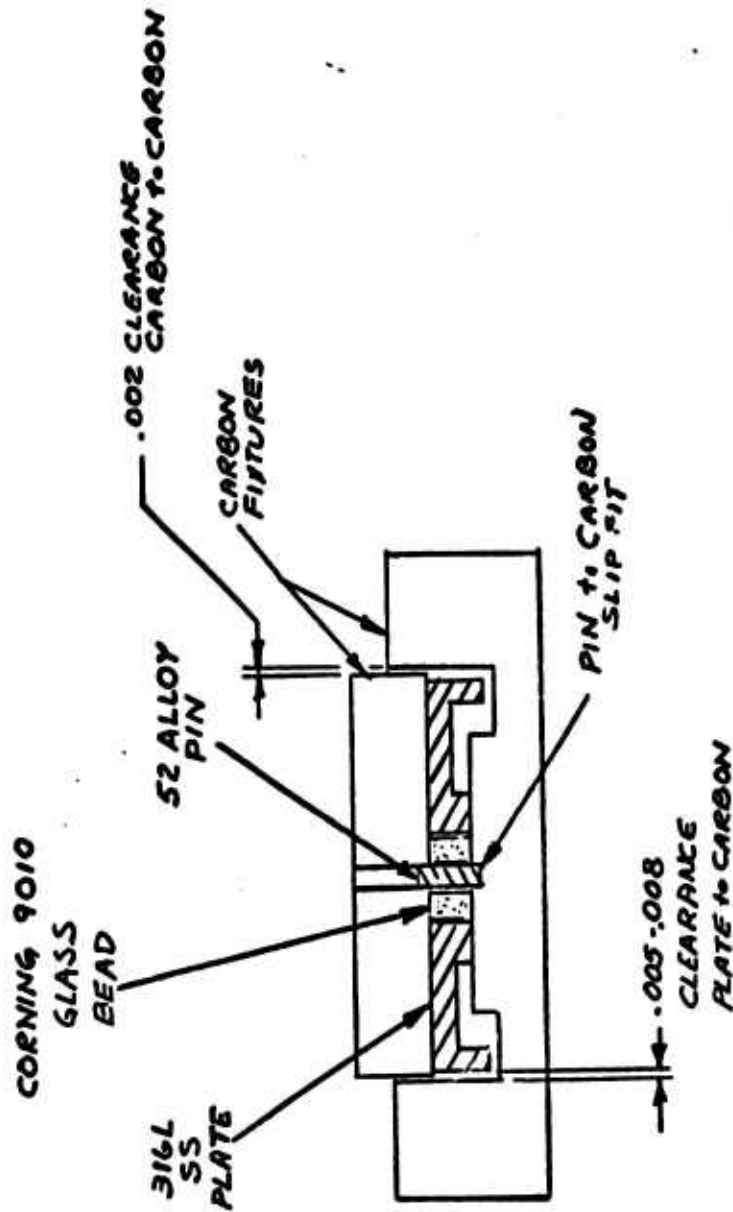
DESCALE AND BRIGHT FINISH

A. Descale

1. Put headers in cold descaling solution (Diversey Chem. Co.)
2. Place on hot plate
3. Bring to boil and boil for 1 hour and stir
4. Rinse 212°F water
5. Gradually cooler water to cold water
6. Two water, two methanol rinses
7. Oven dry

B. Bright Dip

1. Put headers in cold bright dip solution (Diversey Chem. Co.)
2. Place on hot plate
3. Boil 1 hour
4. Rinse water boiling
5. Gradually cooler water to cold water
6. Two water, two methanol rinses
7. Oven dry

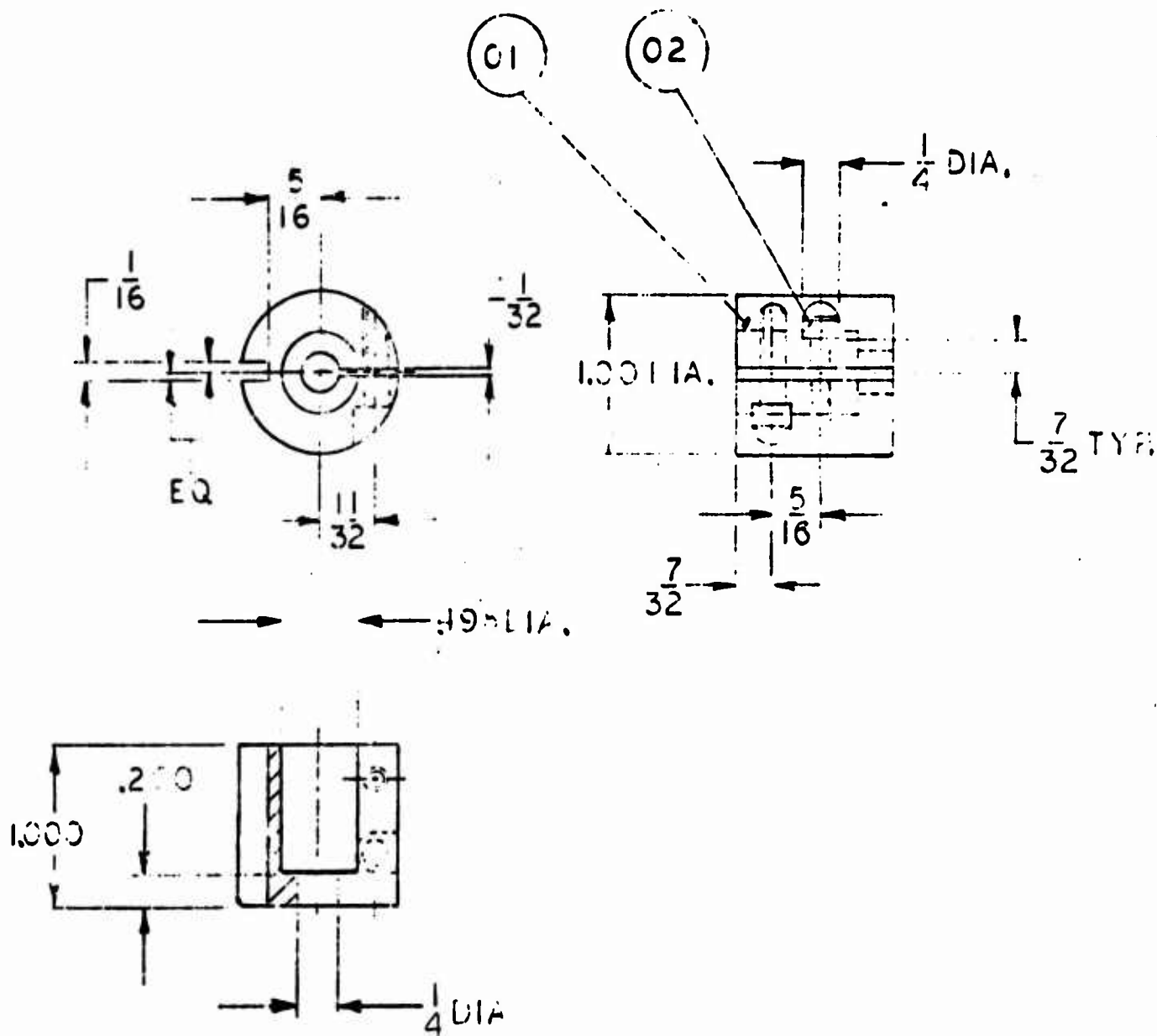


Bead Size	
ID	.078 / .081
OD	.134 / .131

"S" Seal Fitting
Dimensions

APPENDIX C
DRAWINGS REFERENCED IN TEXT

ASK 72004001
DSK T9275567
CSK T9275568
BSK T9275569
CSK T9275570
CSK T9275574
CSK T9275603



3 PLACE DECIMALS $\pm .002$
 2 " " $\pm .01$

02	2	SH.C.S.	6-32 X 3/8	
01	1	COPPER	1" DIA. X 1"	
IT	QTY	MAT'L	SIZE	
HEAT SINK FOR PT. NO. 9275567				
REV				
SIZE	CODE IDENT NO.	DRAWING NO.		
A	99325	ASK 72004001		
SCALE FULL		G 2666	SHEET. 1 OF 1	

106

Handwriting practice lines with dashed lines and arrows indicating stroke direction.

.E35 MAX

EEW>-----G

NOTE

PLATE ASSEMBLY, TERMINAL, MACHINED
9275568

AMPUL. ELECTROLYTE
9275981

DISC. INSULATOR
9275578

— SHIM, AMF
9275579

NOTES:-

- 1-SPEC MIL-A-240 APPLIED
2-NO DETECTABLE LEAKS PERMISSIBLE AT MASS SPECTROMETER
EQUIPMENT SENSITIVITY OF 2.0⁻¹⁰ PER SECOND OF HELIUM.
3-WELDED LEAD TO BE FULLY COVERED WITH KM RUBBER TO
METAL CEMENT, DAG NO. 9275592
4-STAMP IN BLACK PRINTERS INK THE CHARACTERS: 9275592

3756

SHUPA FORM 1041 DEC 69

FCF

References

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A	CHANGED DRAWING TO SHOW NEW 9275579, DIM. 02 WALL THICK.	3-14-72	12/
E	REV PER 1 FSC 0033	6-25-73	12/
C	REV PER EC 4 PSF 0048	7-31-74	12/

NOTE 4

(B)

.635 MAX

040 (2)
RSW
NOTE 3

CELL ASSEMBLY
9275571

(C)

(A)

SHIM, AMPUL SUPPORT
9275579

FOR ASSOCIATED LISTS, SEE 9275567.

PART NO. 9275567

APPLICATION		DIMENSIONS 10 15 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100	DO NOT SCALE DRAWING DIMENSIONS SHOWN ARE FOR INFORMATION ONLY. DIMENSIONS TO BE USED IN DETAILING.	DATE: 28 MARCH 72 BY: [] FOR: [] APP: []		U.S. ARMY MUNITIONS COMMAND PICATINNY ARSENAL, DOVER, NEW JERSEY 07801	
				BATTERY, SINGLE CELL PRIMARY RESERVE			
NEXT ACTY: [] USED IN: []		107	D 19203 T 9275567		SHEET		

A

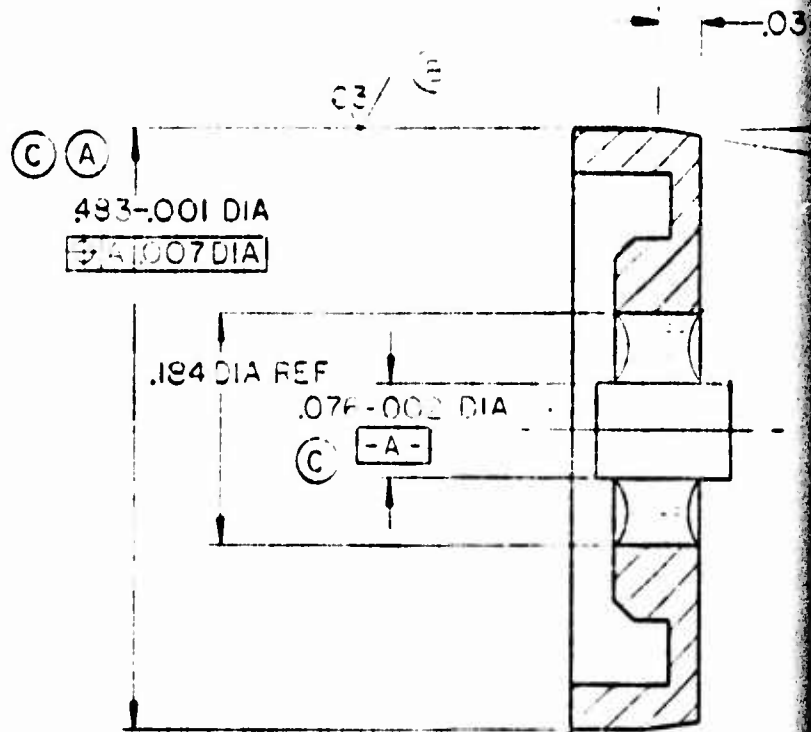
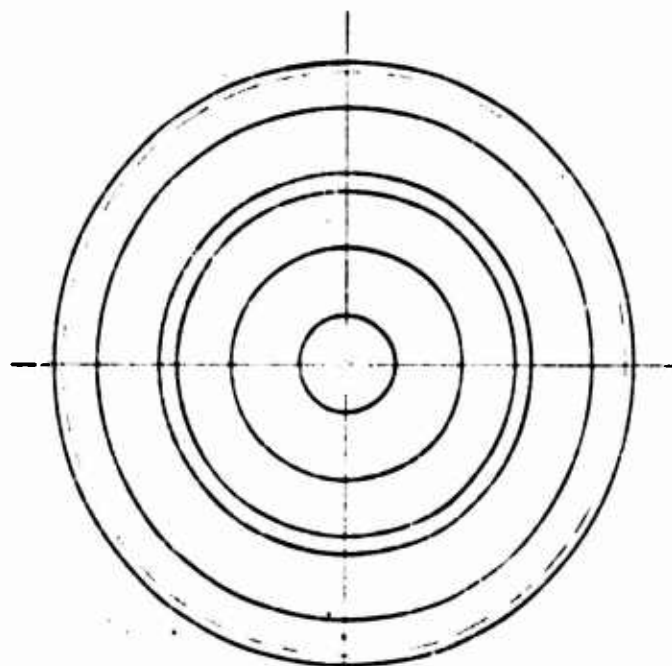


PLATE ASSEMBLY, TERMINAL
9275603

NOTES:-

1 - SPEC MIL-A-2550 APPLIES.

(B)

FOR ASSOCIATED LISTS, SEE 1755-3

		MECHANICAL PROPERTIES	DO NOT SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	DRG
		YP		ENG
		TS		ENG
		EL2	TOLERANCES ON DECIMALS ±	ENG
		RA	FRACTIONS ± ANGLES ±	
9275567	BATTERY-ANGLE CELL PRIMARY SEE 1755-3	BH		
NEXT ASSY	USED ON	RH		
APPLICATION				

108

2

1

REVISIONS			
S.N.	DESCRIPTION	DATE	APPROVAL
A	DIM 43 WAS 452	10-15-72	✓
B	REVIEWED FOR CORRECTION	10-15-72	✓
C	REVIEWED FOR CORRECTION	10-15-72	✓

.03+.02

E

6+4°

B

D

C

B

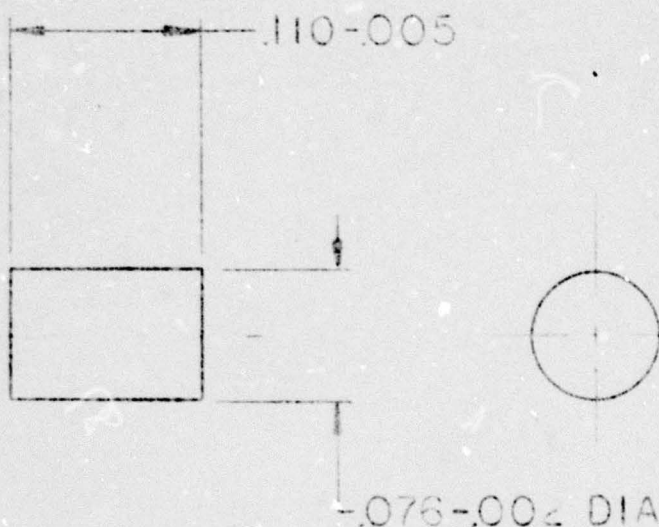
A

2 DIA

PART NO. 9275568

DO NOT SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 16 MARCH 1972		U.S. ARMY MUNITIONS COMMAND PICATINNY ARSENAL, DOVER, NEW JERSEY 07801	
	DRAFTSMAN ENGR. 2/1	CHECKER ENGR. 6/1	FLATE ASSEMBLY, TERMINAL, MACHINED	
DRAFTSMAN ENGR.		DRAFTSMAN ENGR.		
SCALE 10/1		CODE IDENT NO C 19203 T 9275568		
UNIT WT		SHEET		

A



NOTES:-

1 - SPEC MIL-A-2550 APPLIES.

(A) 2 - MATERIAL:-WILFUR P. DRIVER-ALLOY 52

3 - FINISH ¹²⁵✓ ALL SURFACES.

		MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	
		YP		TOLEANCES ON DECIMALS ±	DRA
		TS		FRACTIONS ± ANGLES ±	ENG
		EL2			ENG
		RA		MATERIAL	SU
		BH		HEAT TREATMENT	AP
		RH		FINAL PROTECTIVE FINISH	
APPLICATION					
DO NOT	APPLY PART NO.				
DO	AS SPECIFIED				

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A	REV PER E073FSC-0033	6-25-73	EH

B

PART NO. 9275569

ORIGINAL DATE OF DRAWING
8 MARCH 1972

PICATINNY ARSENAL DOVER, NEW JERSEY

DRAFTSMAN

CHECKER

ENGR

ENGR

ENGR

ENGR

SUBMITTED

APPROVED

PIN, TERMINAL

SIZE

CODE IDENT NO.

B

19203

T

9275569

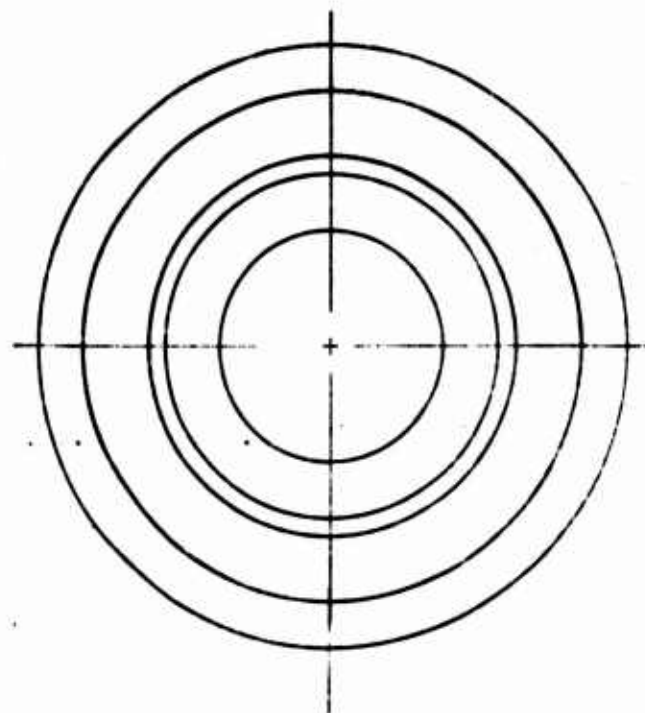
SCALE

10/1

UNIT WT.

SHEET

A



.015 +0.002 X 45°

.410 +0.005 DIA

.305 -0.005 DIA

.184 +0.002 DIA

-A-

(B) (A)

.507-.014 DIA

⊕ A .002 DIA

NOTES:-

1 - SPEC MIL-A-2550 APPLIES.

2 - MATERIAL:- STEEL BAR, CORROSION RESISTING, CLASS 316L, (B)
CONDITION A, SPEC QQ-S-766.3 - FINISH ¹²⁵√ ALL SURFACES. (B)

		MECHANICAL PROPERTIES		DO NOT SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	
		VP		TOLERANCES ON DECIMALS ±	
		TS		FRACTIONS ±	ANGLES ±
		FL2			
		RA			
		BH			
		RH			
(B)	9275203	BATTERY SINGLE CELL PRIMARY RESERVE			
	NEXT ASSY	USED ON			
	APPLICATION				

002 X 45°

2

1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A	DIM. 493 WAS 492	9-15-72	<i>ASH</i>
B	REV PER E073F SC-0033	2-25-73	<i>ASH</i>

(B)

B

5 DIA

.184±.002 DIA

-A-

.010 R MAX

.025 ±.005

.070 ±.003

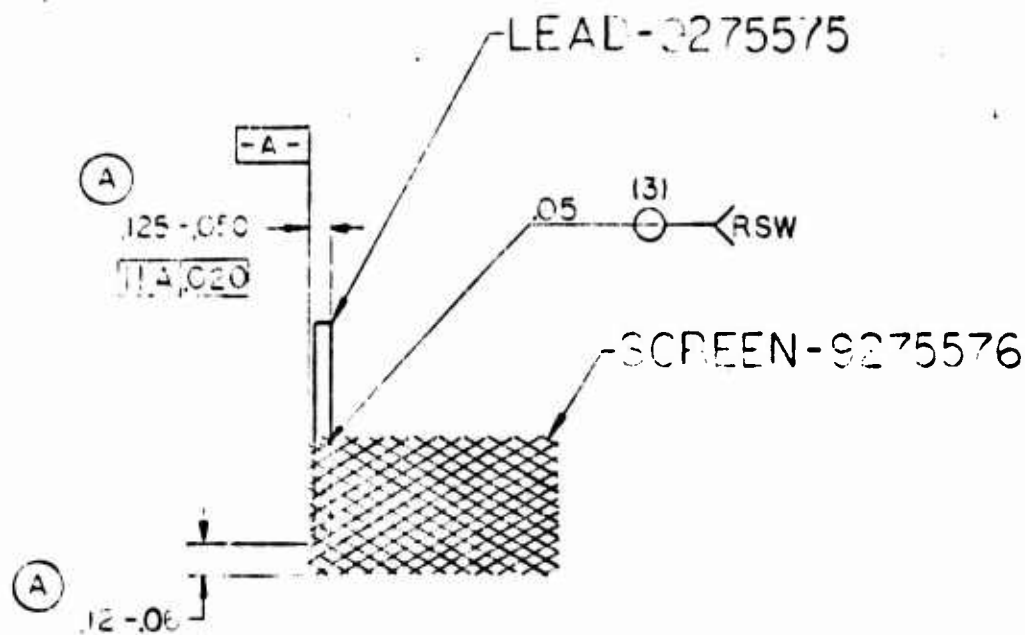
.102±.004

PART NO. 9275570

110

DO NOT SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		ORIGINAL DATE OF DRAWING 15 MARCH 1972		U.S. ARMY MUNITIONS COMMAND PICATINNY ARSENAL, DOVER, NEW JERSEY 07801	
		DRAFTSMAN JS	CHECKER <i>ASH</i>	PLATE, TERMINAL	
TOLERANCES ON DECIMALS ±		ENGR <i>3/1</i>	ENGR <i>6/1</i>		
FRACTIONS ± ANGLES ±		ENGR	ENGR	SIZE C	
				CODE IDENT NO 19203	T 9275570
				SCALE 10/1	UNIT WT. 15 FEET

A



NOTES:-

1 - SPEC MIL-A-2550 APPLIES.

FOR ASSOCIATED LISTS, SEE 9275574

		MECHANICAL PROPERTIES	DO NOT SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	
		YP		DRAFT
		TS		ENGR
		El2	TOLERANCES ON DECIMALS ±	ENGR
		RA	FRACTIONS ± ANGLES ±	
9275572	BATTERY, SINGLE CELL, PRIMARY RESERVE	BH		
NEXT ASSY	USED ON	PH		
APPLICATION				

2

1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A	REV PER 9275574-0041	7-15-73	

D

B

C

B

PART NO. 9275574

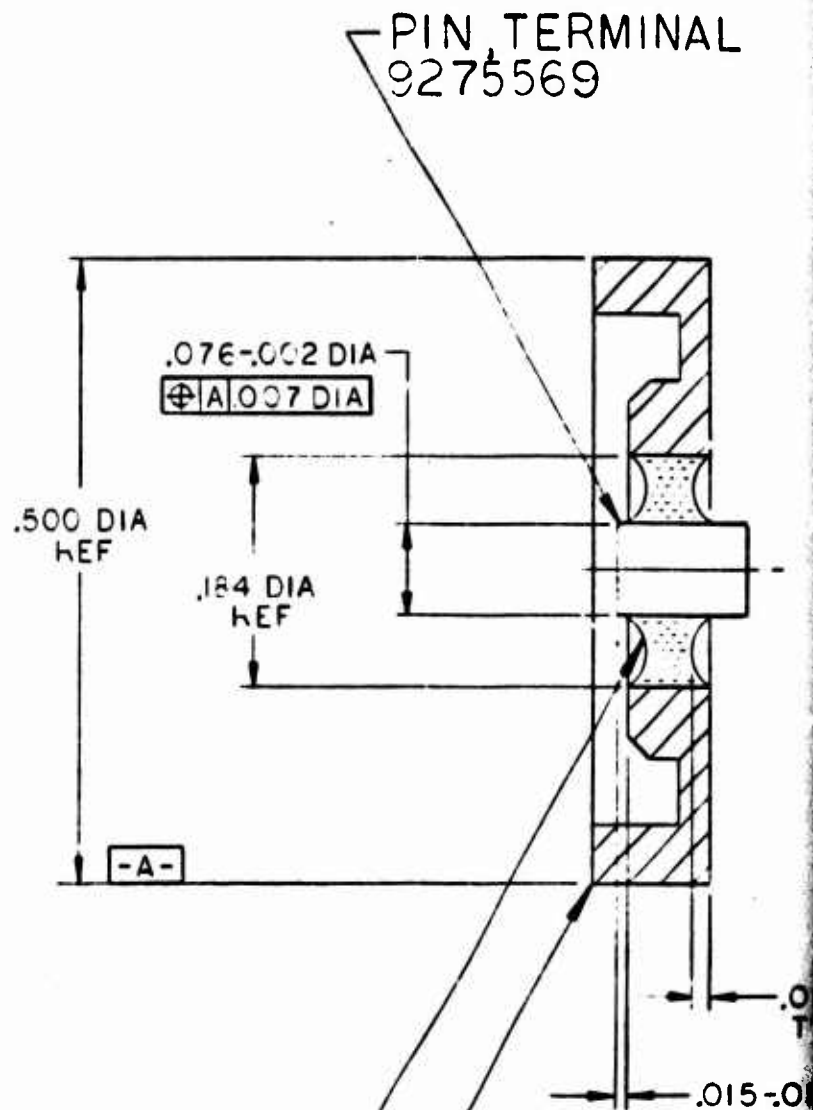
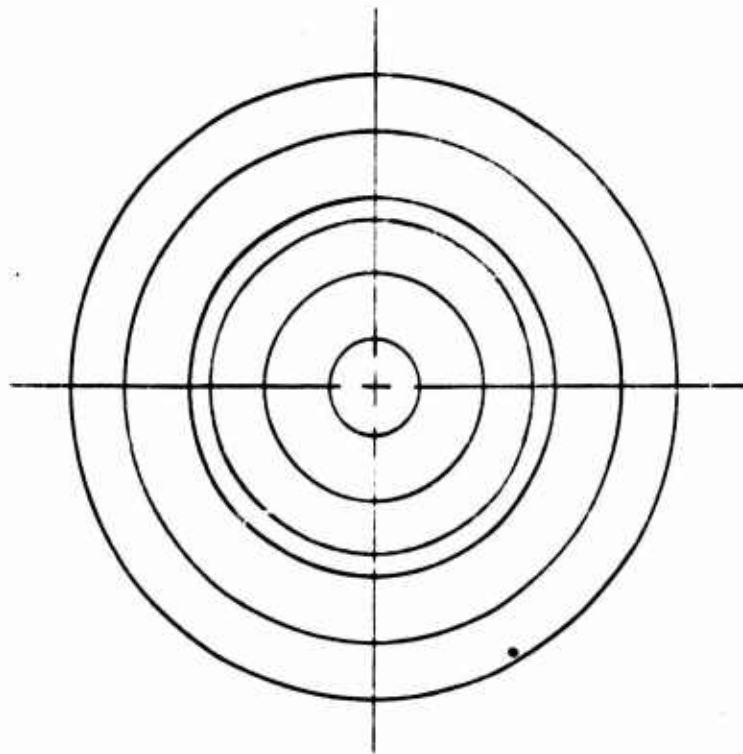
111

SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DECIMALS ± ANGLES ±	ORIGINAL DATE OF DRAWING 20 MARCH 1972		U.S. ARMY MUNITIONS COMMAND PICATINNY ARSENAL, DOVER, NEW JERSEY 07801	
	DRAFTSMAN J.S.	CHECKER J.S.	SCREEN ASSEMBLY, ANODE	
	ENGR R.H.	ENGR J.S.		
	ENGR	ENGR		
	SIZE C	CODE IDENT NO 19203	T	9275574
	SCALE 2/1	UNIT WT	SHEET	

A

9275576

A



NOTES:-

- 1- SPEC MIL-A-2550 APPLIES.
- 2- GLASS IS NOT TO EXTEND ABOVE ANY METAL SURFACE.
- 3- NO DETECTABLE LEAKS PERMISSIBLE AT MASS SPECTROMETER EQUIPMENT SENSITIVITY OF 2×10^{-8} CC/SECOND OF HELIUM.
- 4- FINISHED ASSEMBLY TO BE FREE OF OXIDES.

FOR ASSOCIATED LISTS, SEE 9275603

		MECHANICAL PROPERTIES		DO NOT SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	
		YP		TOLERANCES ON DECIMALS ±	DRAW
		TS		FRACTIONS ± ANGLES ±	ENG
		EL2			ENG
		RA			
		BH			
		RH			
9275568	BATTERY SINGLE CELL EFFICIENCY BEFORE				
NEXT ASSY	USED ON				
APPLICATION					

PIN TERMINAL
9275569

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A	REV PER EOTR-SC-0009	11-29-73	ASW

B

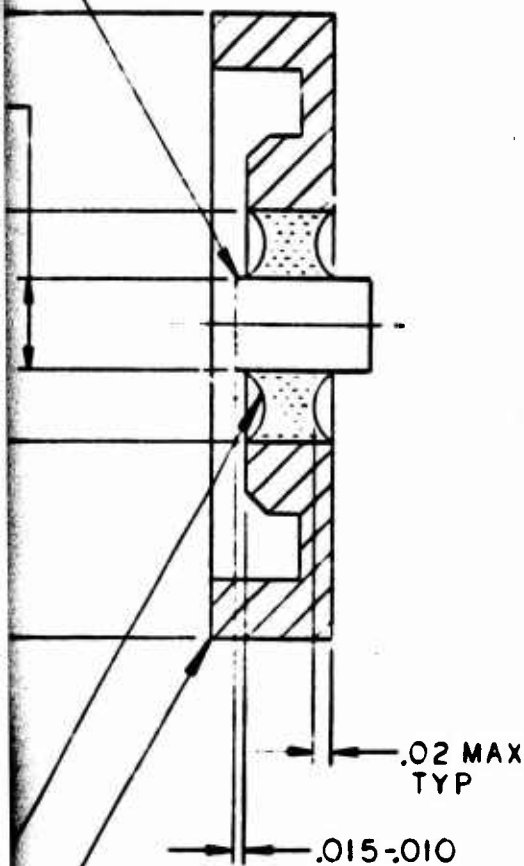


PLATE TERMINAL
9275570

SS
5597

PART NO. 9275603 112

DO NOT SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± ANGLES ±	ORIGINAL DATE OF DRAWING 20 JUNE 1973		U.S. ARMY MUNITIONS COMMAND PICATINNY ARSENAL, DOVER, NEW JERSEY 07801	
	DRAFTSMAN	CHECKER	PLATE ASSEMBLY, TERMINAL	
	ENGR <i>JS</i>	ENGR <i>JS</i>		
	ENGR <i>JS</i>	ENGR <i>JS</i>		
		SIZE C	CODE IDENT NO. 19203	T 9275603
		SCALE 10/1	UNIT WT.	SHEET

↑

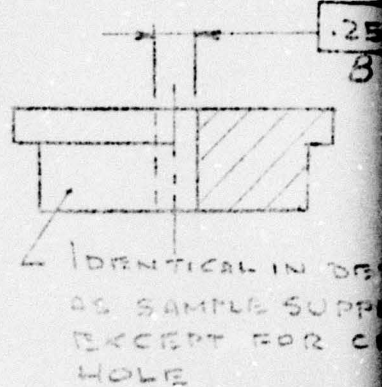
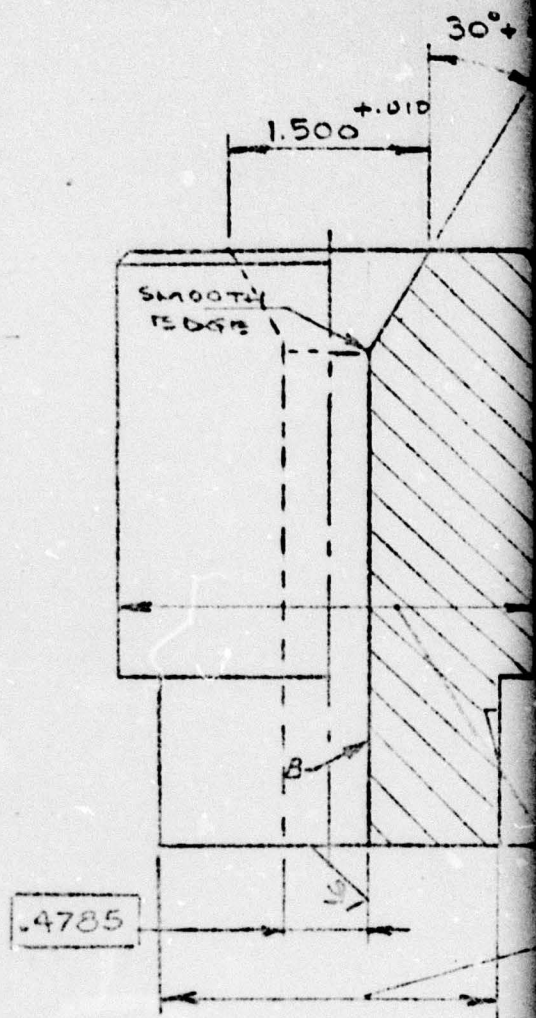
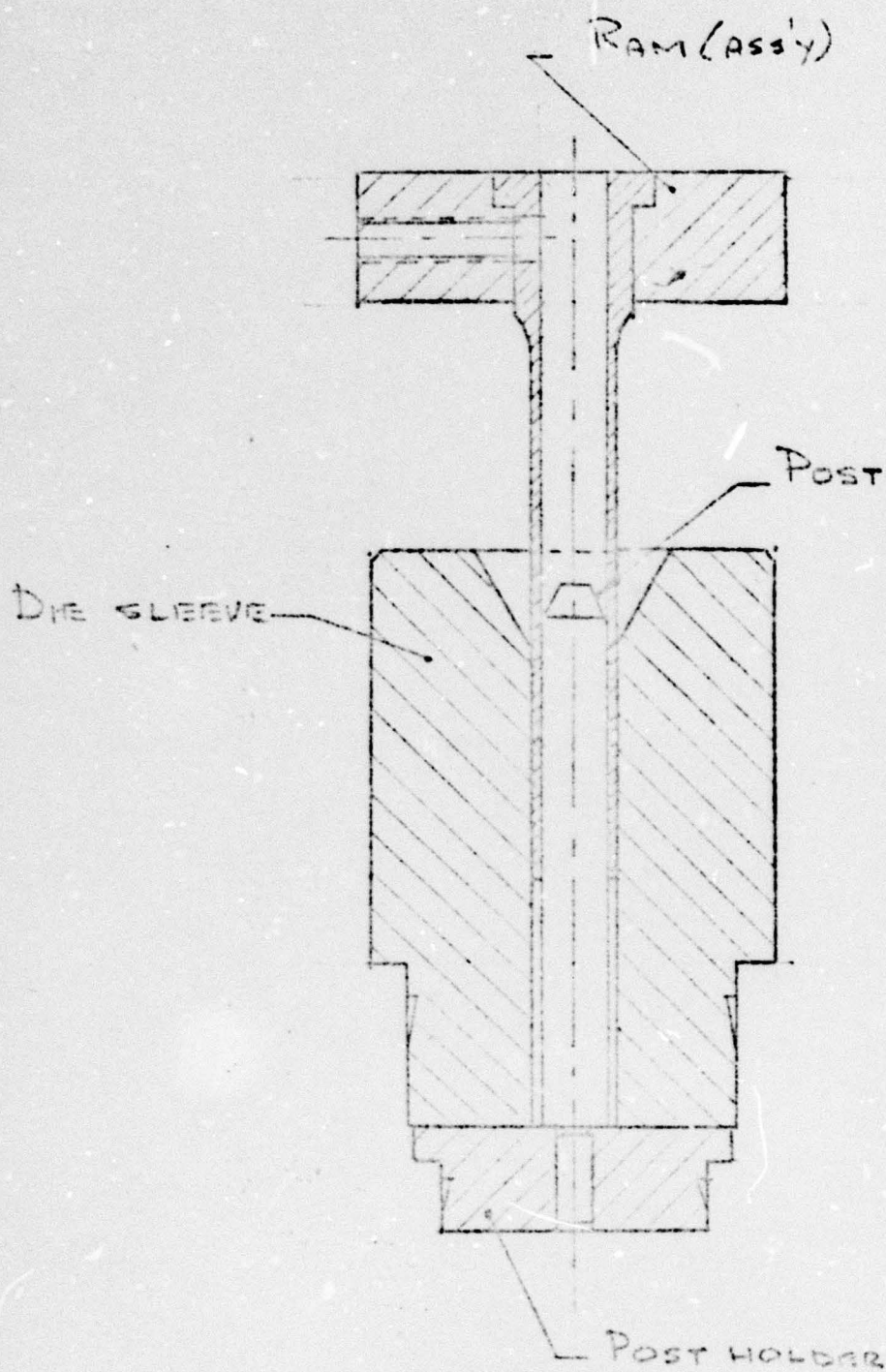
APPENDIX D
CATHODE TOOLING SKETCHES

BSK 72003868
ASK 72003869
ASK 72003870
ASK 72003871
ASK 72003872
BSK 72003873
BSK 72003874
ASK 72003875
ASK 72003876
ASK 72003877
ASK 72003878
ASK 72003879
ASK 72003880
DSK 72003881

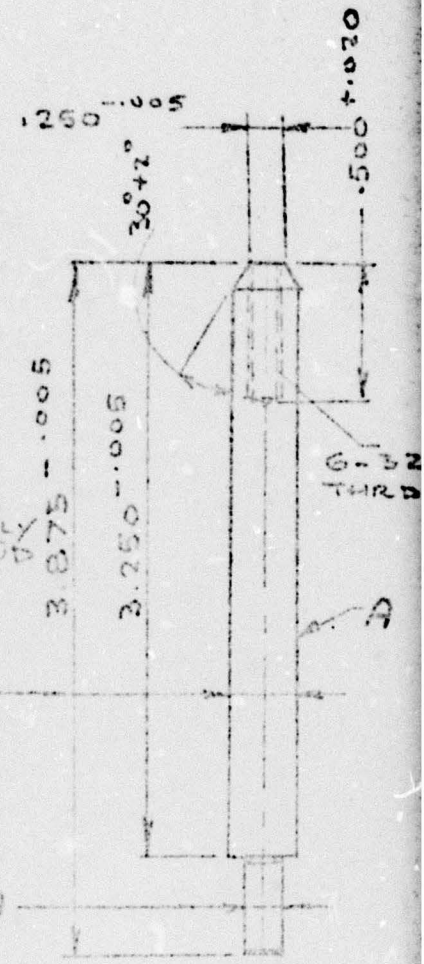
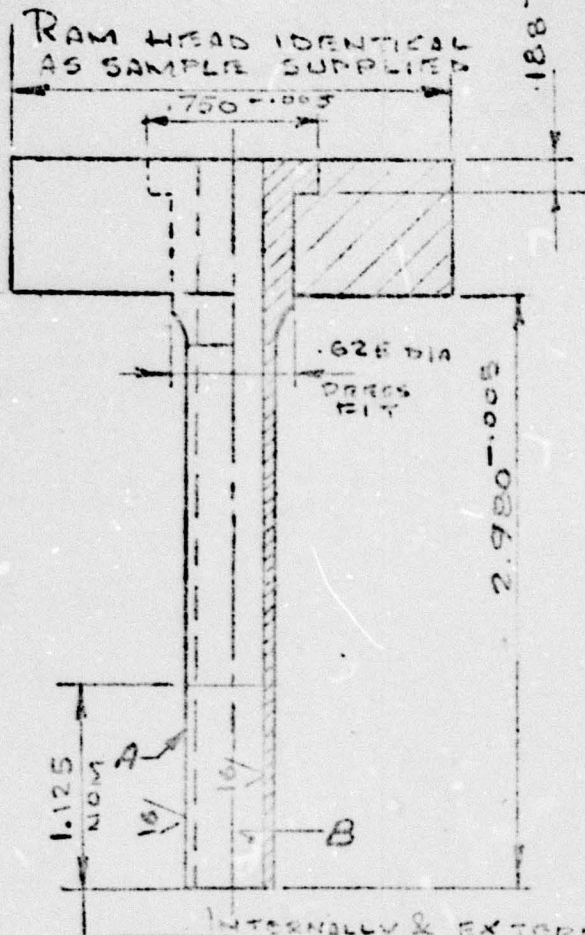
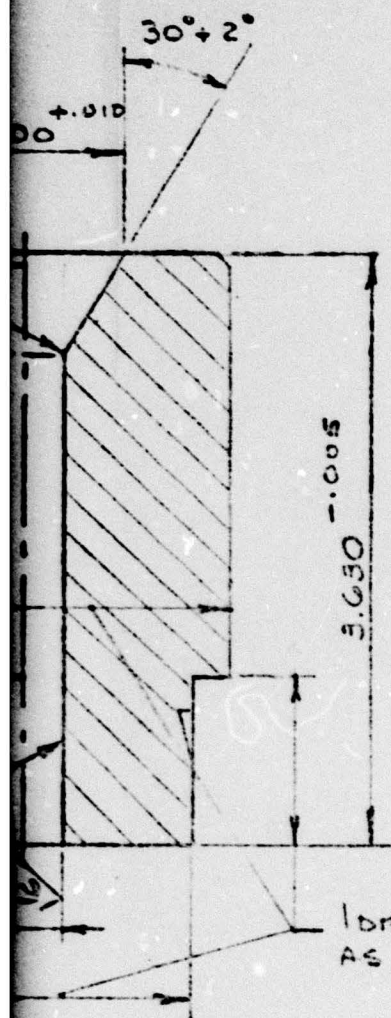
APPENDIX C
DRAWINGS REFERENCED IN TEXT

ASK 72004001
DSK T9275567
CSK T9275568
BSK T9275569
CSK T9275570
CSK T9275574
CSK T9275603

A



B



MAT'L: VEGA

CATHODE DIE C-2600

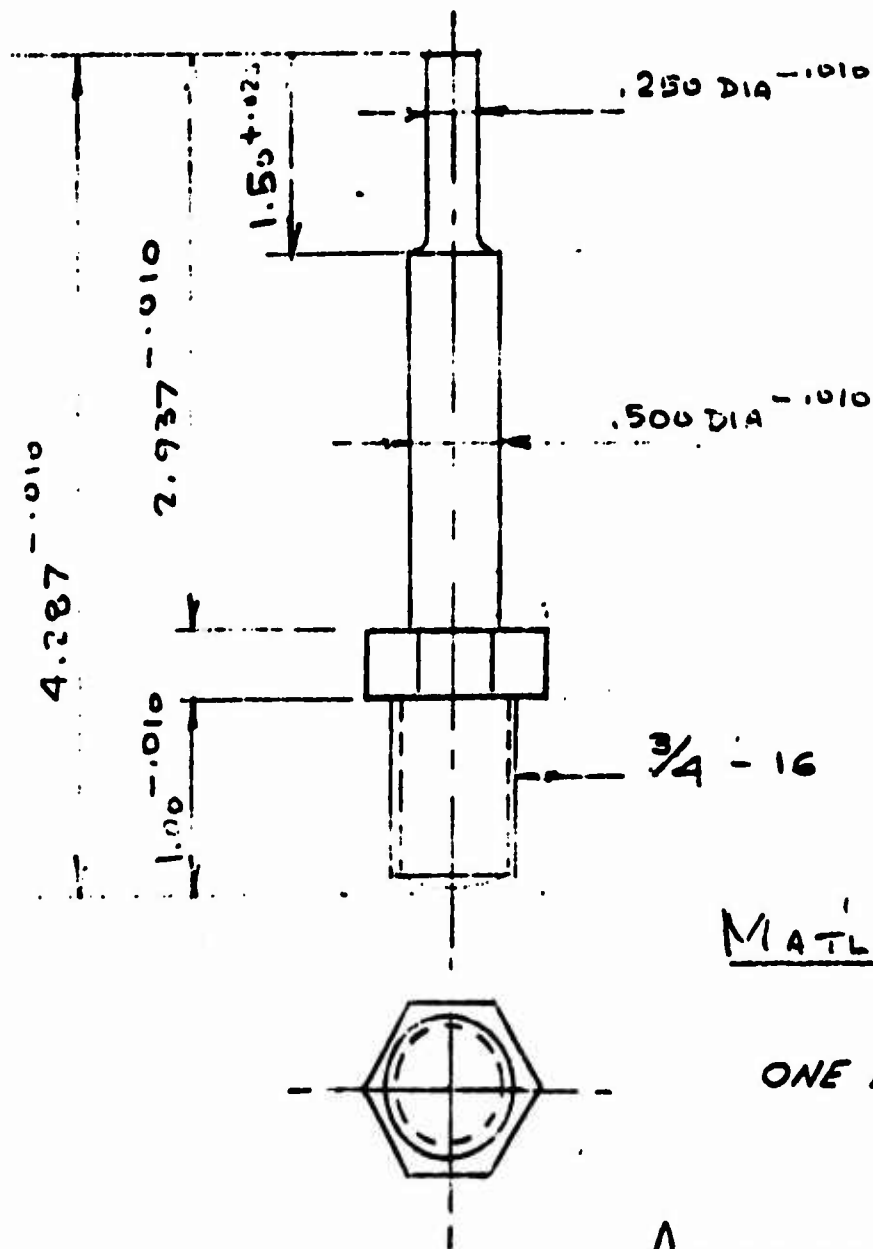
E.C.W. 5/2/73

NOTE: A-B MATCHED FIT

PRELIMINARY SKETCH
PART NO. BSK-7003868
VOID UNTIL
DRAWING RELEASE

115

REV 10-2-73



MATL: 303 CRES

$\frac{7}{8}$ HEX-STOCK

ONE REQUIRED

ADAPTOR

(ROD EJECTOR)

F.C.W 8/22/73

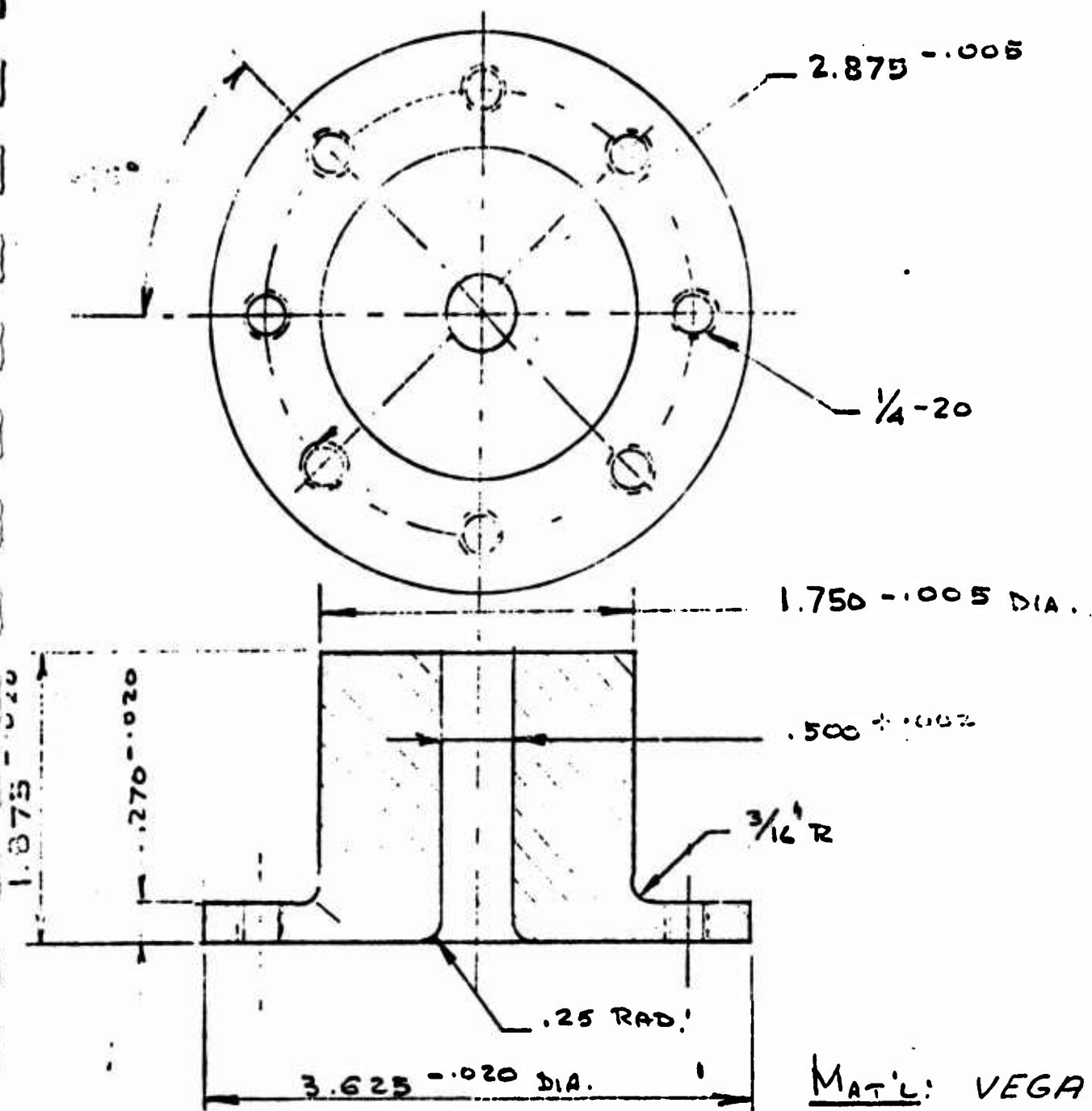
PRELIMINARY

SKETCH

PART NO. ASK-22003269

VALID UNTIL

DRAWING RELEASE



MAT'L: VEGA
HARDENED
ONE REQ'D

CASE GUIDE BUSHING

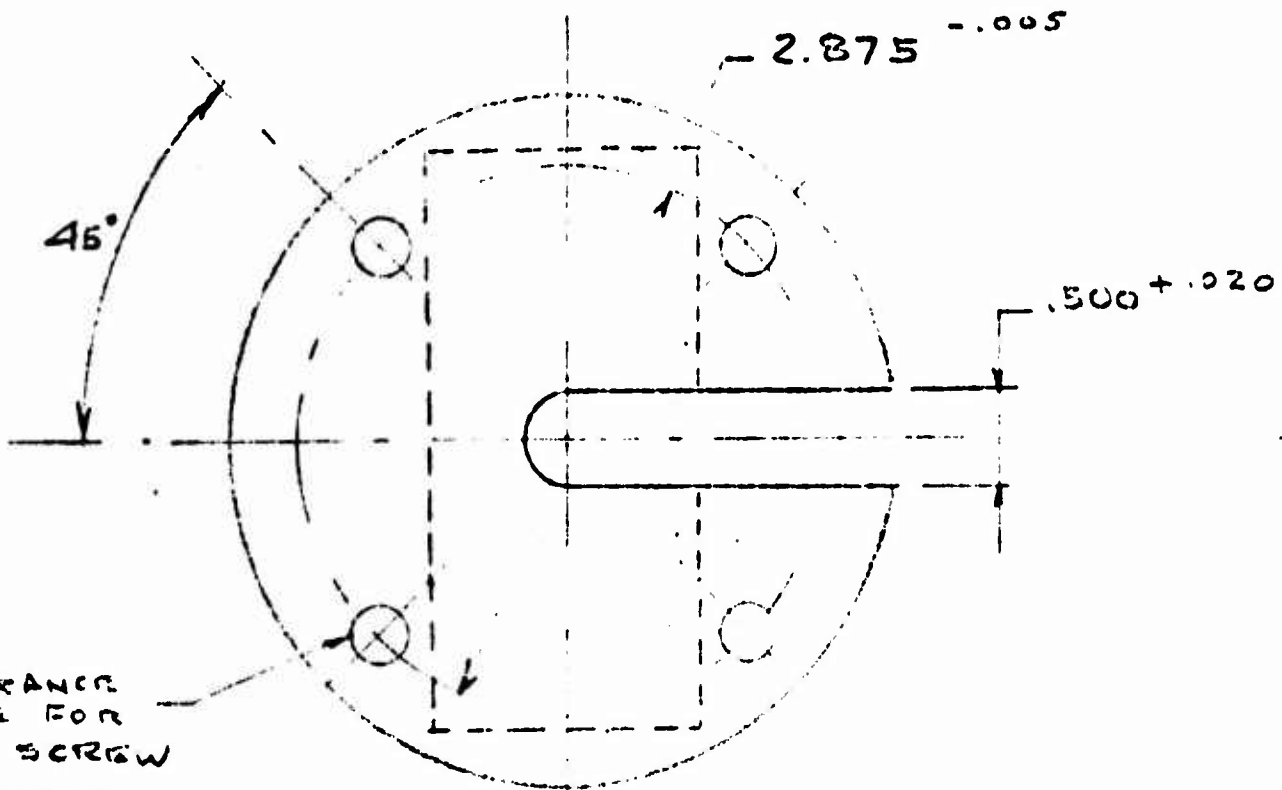
E.C.W. 8/23/73

117

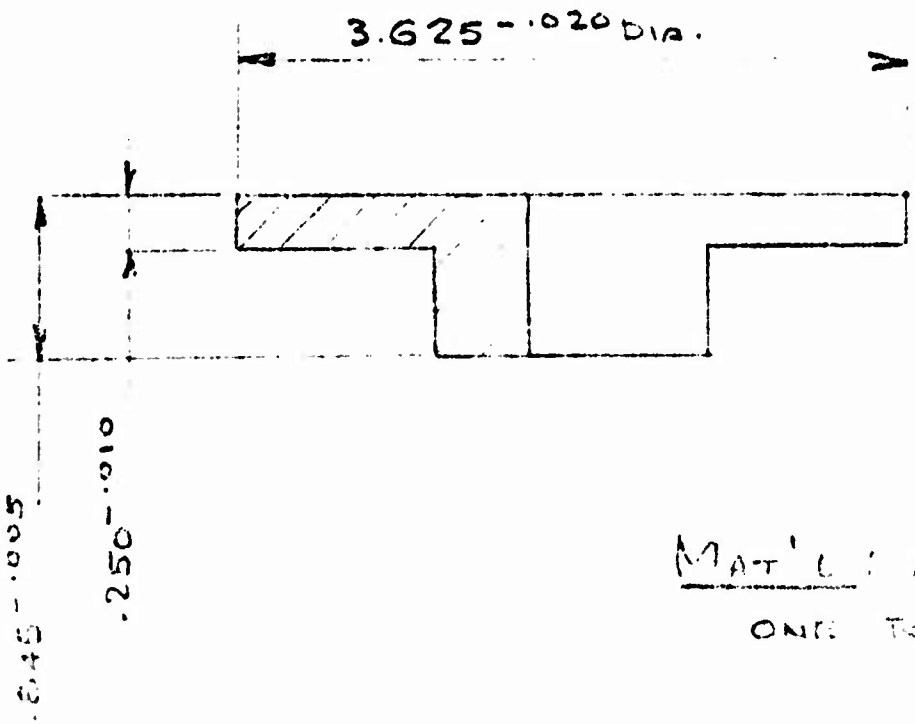
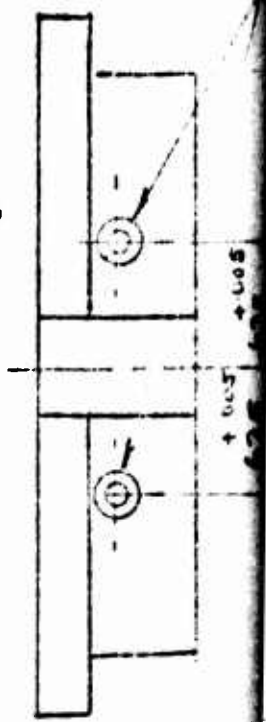
PRELIMINARY
SKETCH
PART NO. ASK-72003872
VALID UNTIL
DRAWING RELEASE

REV 1

A

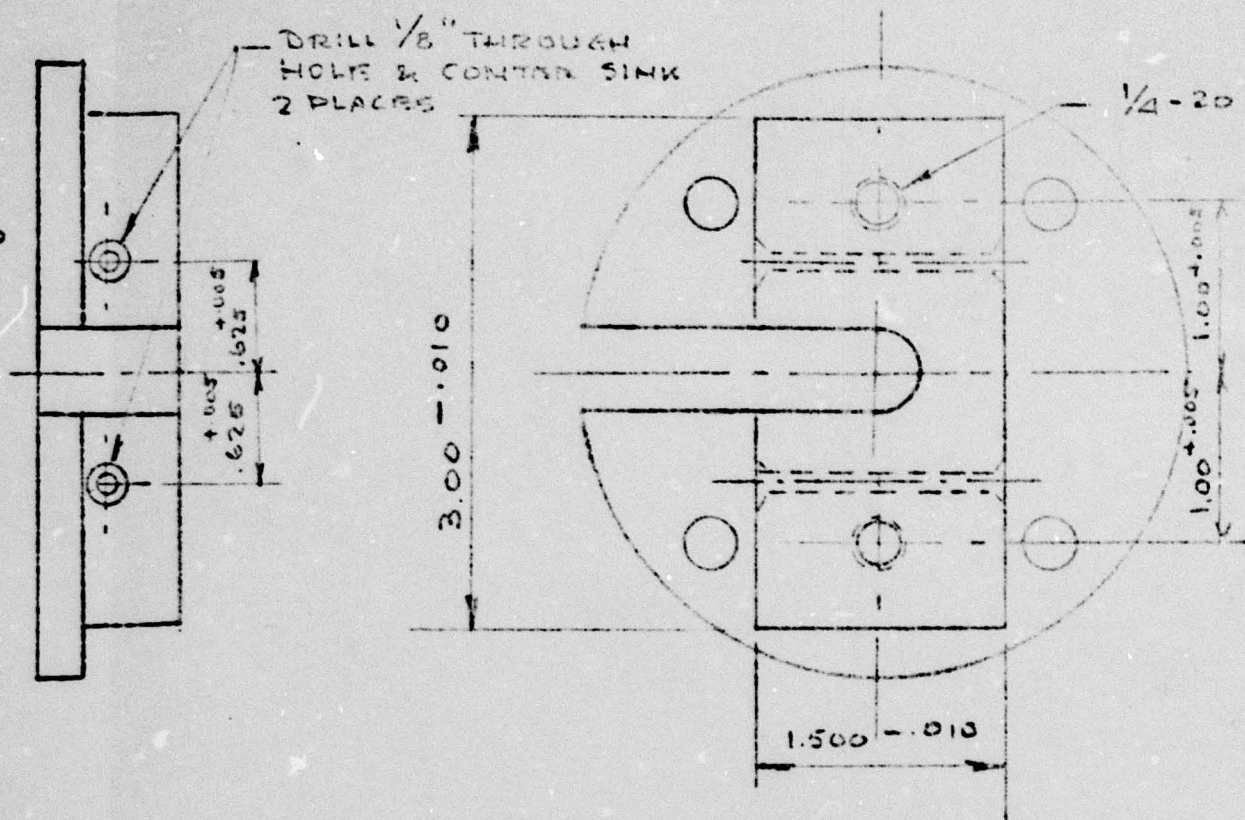


CLEARANCE
HOLE FOR
1/4" SCREW
4 PLACES.



MAT'L: ALUMINUM.
ONE REQ'D.

B



FEEDER MAGAZINE CHAMBER

E.C.W. 8/23/73

118

PRELIMINARY
SKETCH
PART NO. BSK-72203873
VALID UNTIL
DRAWING RELEASE

20.50 $\pm .02$

19.00 $\pm .020$

A

.500 $\pm .020$

.375 $\pm .020$

.250 $\pm .005$

2.00 $\pm .010$

3.00 $\pm .005$

1.700 $\pm .010$

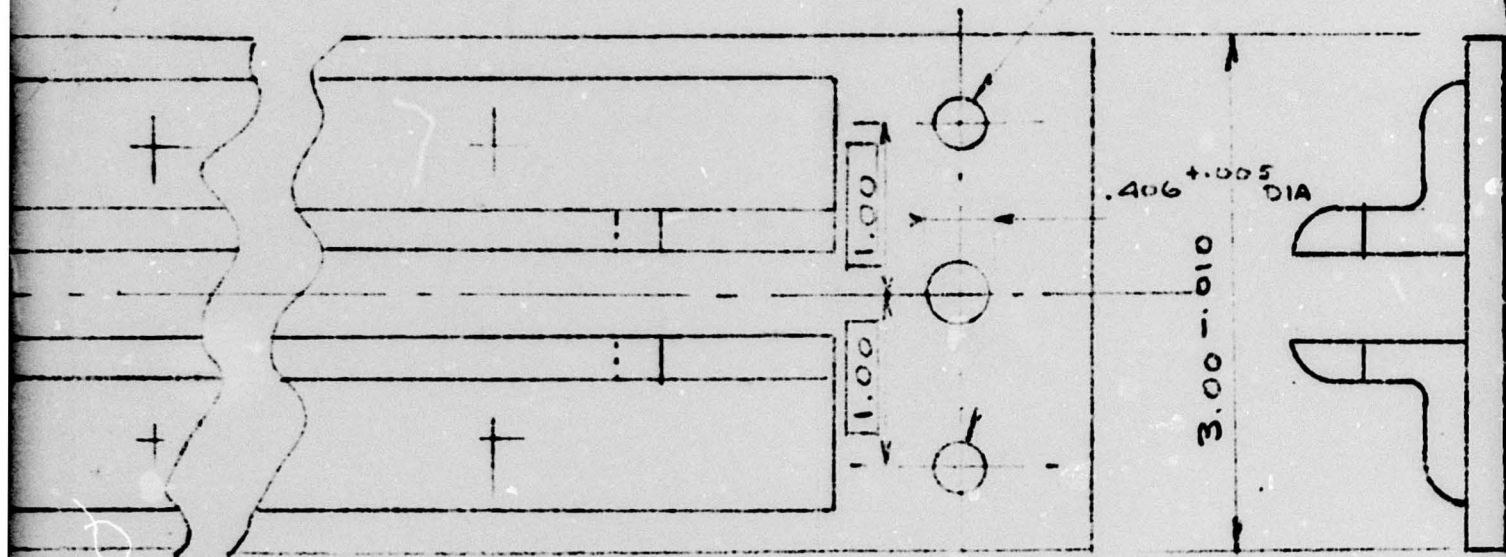
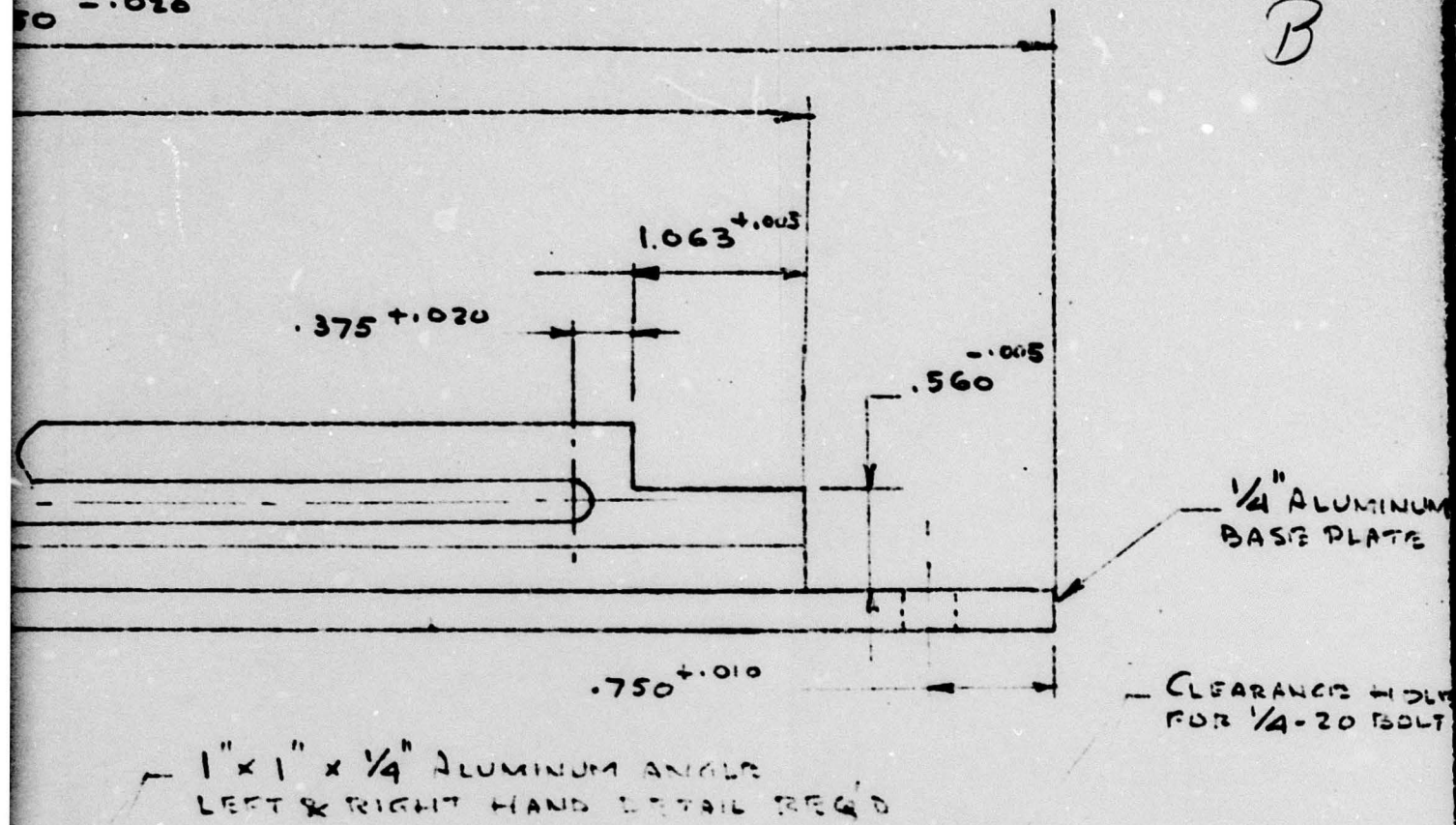
5 SPACES

.500 $\pm .010$

MOUNT TRAILS ON BASE
PLATE WITH SELF TAPPING
SCREWS

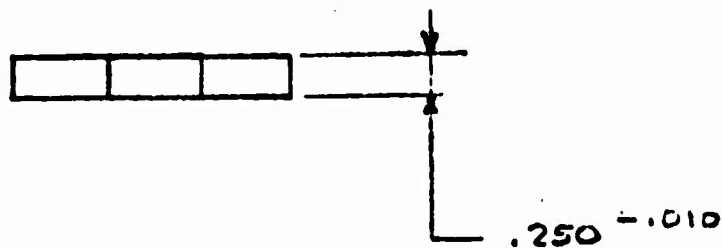
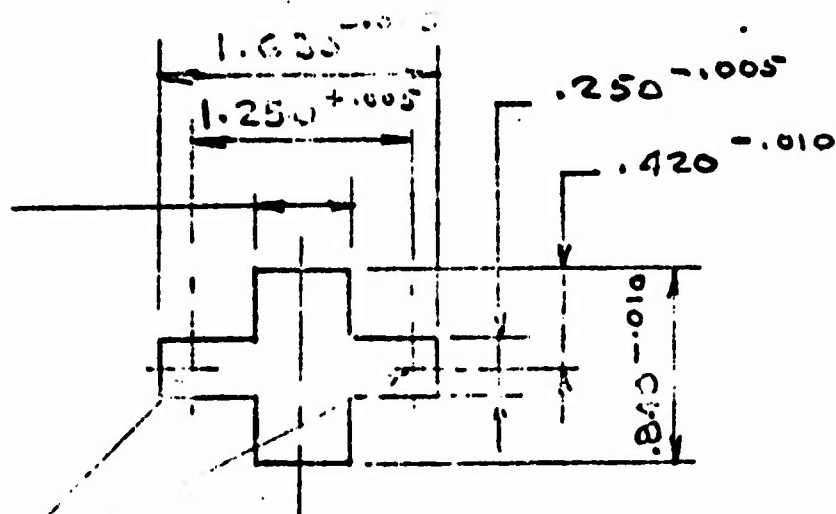
50 - .020

B



MAGAZINE RAIL

PRELIMINARY B.C.W 6/22/73
SKETCH
PART NO. BSK-72003874
VALID UNTIL
DRAWING RELEASE **119**

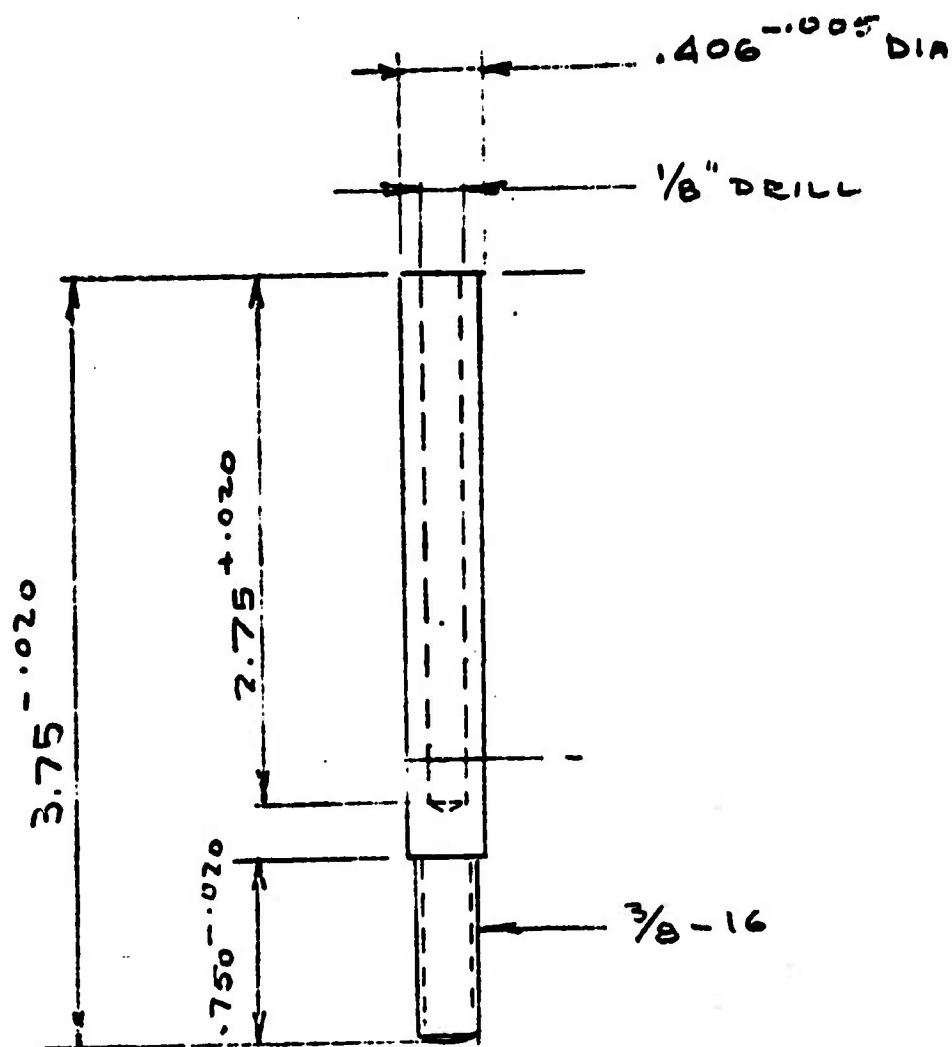


MAT'L: ALUMINUM.
ONE REQ'D.

MAGAZINE PUSHER PLATE.

E.C.W. 8/23/73

PRELIMINARY
SKETCH
PART NO. ASK-72003375
VALID UNTIL
DRAWING RELEASE

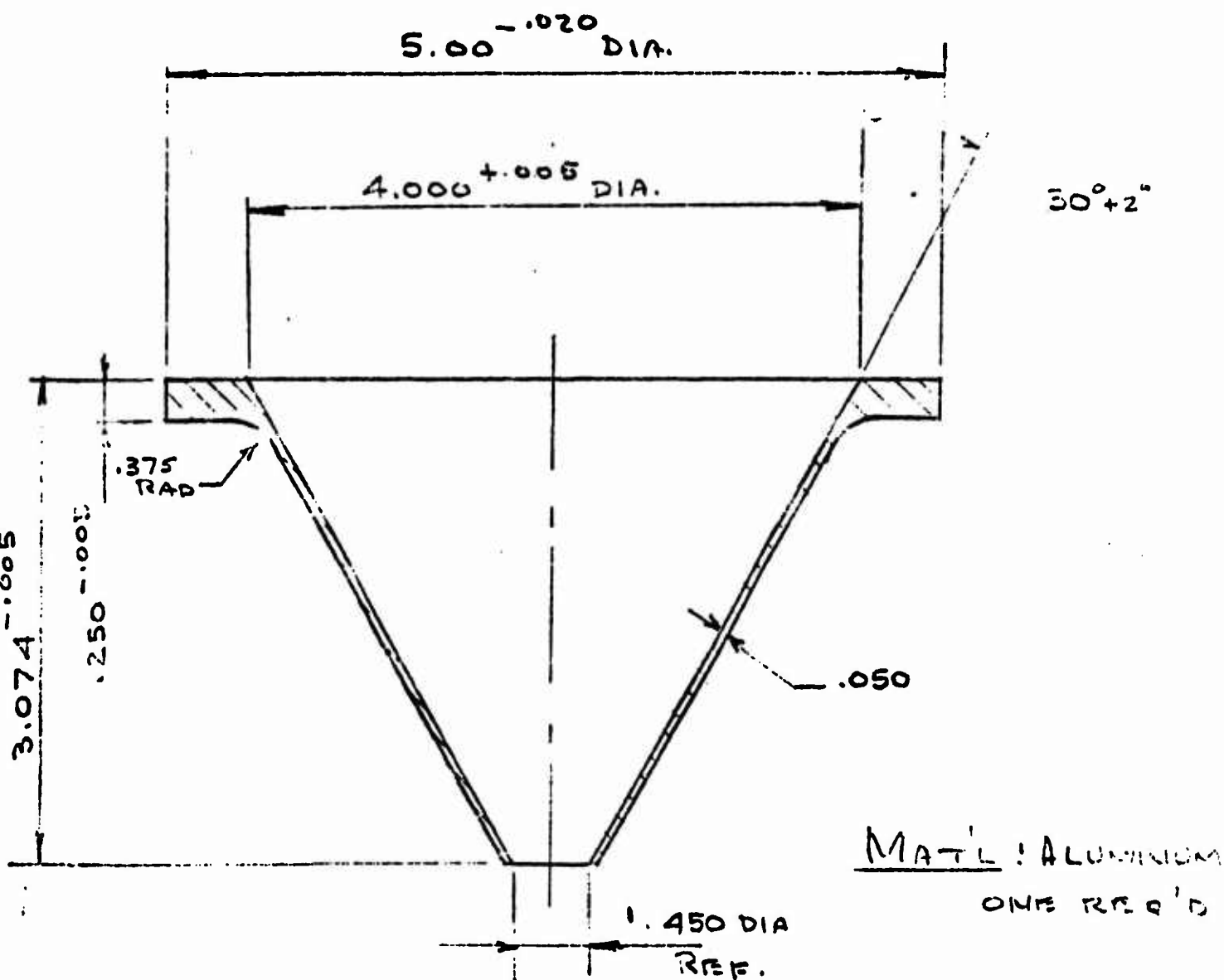


MAT'L : 303 CRES
 UNF REQ'D

CASE PUSH UP & EJECTOR ROD

E.C.W B/23/73

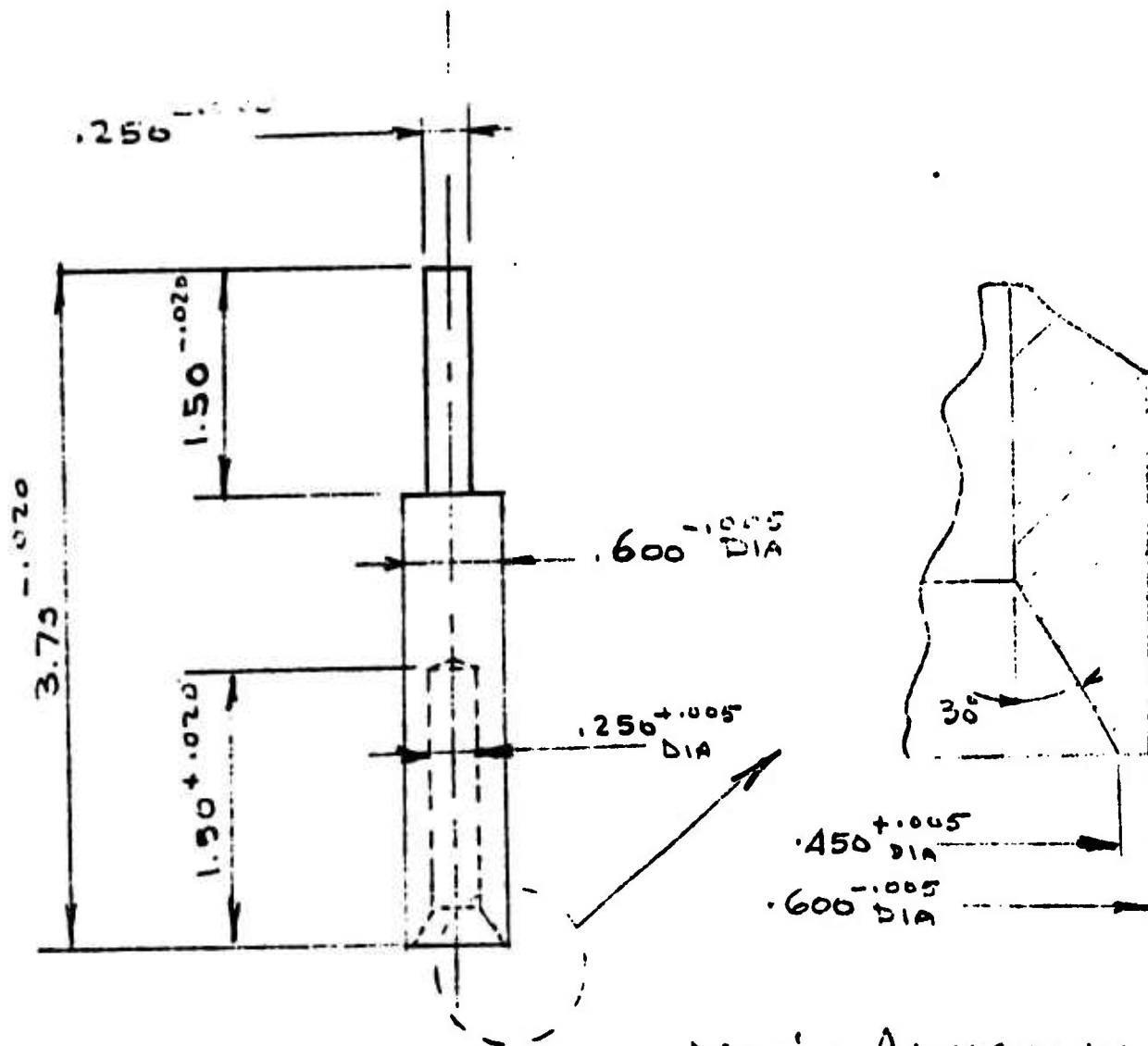
PRELIMINARY
 SKETCH
 PART NO. ASK-72003876
 VALID UNTIL
 DRAWING RELEASE



FUNNEL

E.C.W 8/24/73

PRELIMINARY
SKETCH
PART NO. ASK-72003878
VALID UNTIL
DRAWING RELEASE



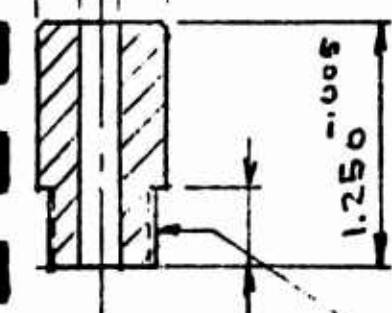
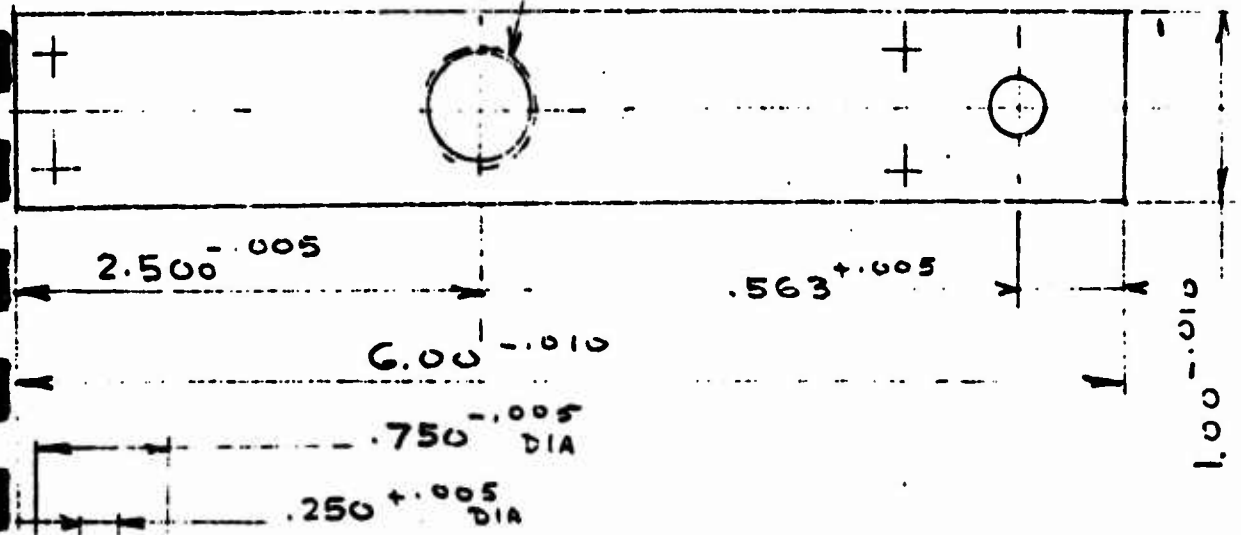
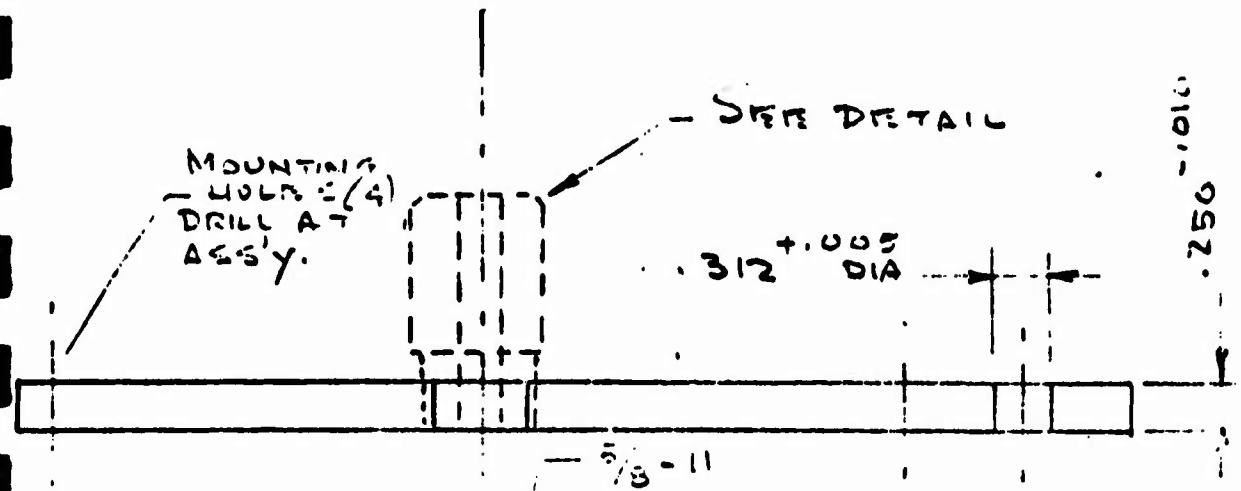
MATL: ALUMINUM
ONE REQ'D

CENTER POST FUNNEL

E.C.W. 8/24/73

124

PRELIMINARY
SKETCH
PART NO. ASK-72003379
VALID UNTIL
DRAWING RELEASE



MAT'L: ALUMINUM
ONE OF EACH REQ'D

MOUNTING BAR, FUNNEL

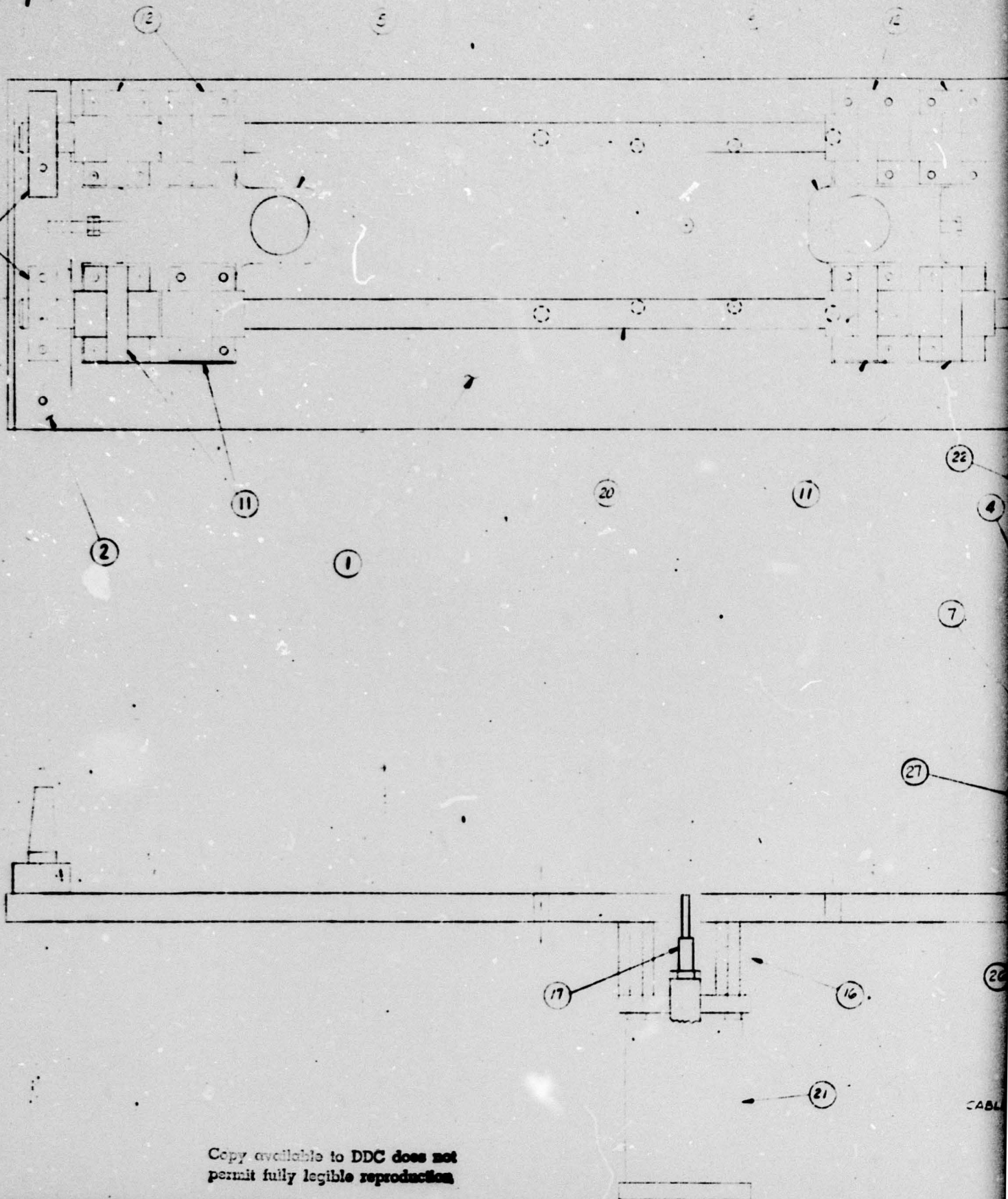
R.C.W. 3/24/73

BUSHING
DETAIL

.375 $\pm .005$

$\frac{5}{8}-11$

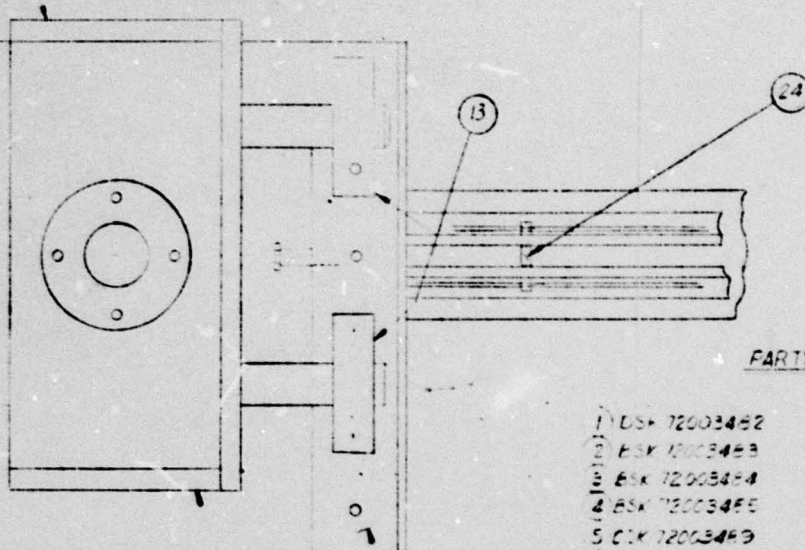
A



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permit fully legible reproduction

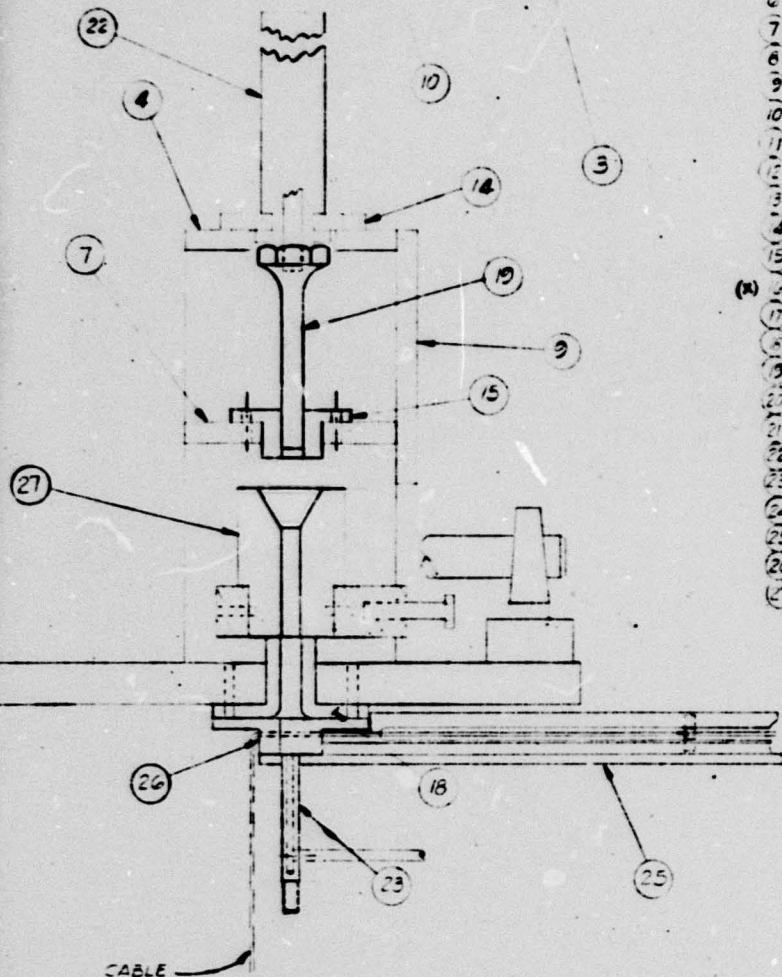
CABLE

B



PARTS LIST

- | | |
|----------------------|---|
| 1 DSK 72003452 | BED |
| 2 BSK 72003453 | LEFT HAND END SUPPORT |
| 3 BSK 72003454 | RIGHT HAND END SUPPORT |
| 4 BSK 72003455 | UPPER SUPPORT PLATE |
| 5 CCK 72003459 | LOWER SLIDE |
| 6 CCK 72003471 | UPPER SLIDE |
| 7 FSK 72003492 | LOWER SUPPORT PLATE |
| 8 BSK 72003493 | REAR MOUNTING PLATE |
| 9 FSK 72003497 | SIDE MOUNTING PLATE |
| 10 BSK 72003498 | FRONT MOUNTING PLATE |
| 11 PB-14-ADU | FOLLOW BLOCK (THOMSON INDUSTRIES) (2 REQ'D) |
| 12 PB-14-KA | " " " " " " |
| 13 CB-14 | SHAFT SUPPORT BLOCK (THOMSON IND) (") |
| 14 BSK 72003499 | UPPER SHEET BUSHING |
| 15 ASK 72003570 | LOWER SUPPORT BUSHING |
| (X) 16 BSK 72003501 | STANDOFF (3 REQ'D) |
| 17 ASK 72003529 | ADAPTOR |
| 18 ASK 72003572 | CASE GUIDE BUSHING |
| 19 ASK 72003571 | CATHODE EJECTOR RAM |
| 20 CLASS 2 1/4 DIA | SHAFT (THOMSON IND) (2 REQ'D) |
| 21 MFL-ANG-4-E-FSF-A | REX HANNA AIR CYLINDER |
| 22 18SD | CLIFFORD AIR CYLINDER - 9 STROKE |
| 23 ASK 72003574 | CASE PUSH-UP & EJECTOR ROD |
| 24 ASK 72003575 | MAGAZINE PUSHER PLATE |
| 25 BSK 72003574 | MAGAZINE RAIL |
| 26 ASK 72003573 | FEEDER MAGAZINE CHAMBER |
| 27 BSK 72003568 | CATHODE DIE |
| MODEL 624 | TOGGLE CLAMP - DESTACO |



(X) NOT DRAWN